TIME DOMAIN ELECTROMAGNETIC SURVEYS FOR ASSISTING IN DETERMINING THE GROUND WATER RESOURCES AT THE PALAWAI BASIN, WINDWARD COAST AND NORTHWEST RIFT PROJECT AREAS ISLAND OF LANAI, HAWAII

9081-000

TIME DOMAIN ELECTROMAGNETIC SURVEYS FOR ASSISTING IN DETERMINING THE GROUND WATER RESOURCES AT THE PALAWAI BASIN, WINDWARD COAST AND NORTHWEST RIFT PROJECT AREAS ISLAND OF LANAI, HAWAII

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September 14, 1994

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1.0 INTRODUCTION

This report contains the results of time domain electromagnetic (TDEM) surveys conducted to assist in determining the ground water resources at three project areas (Palawai Basin, Windward Coast and Northwest Rift) on Lanai Company properties on the Island of Lanai, Hawaii. The locations of the three project areas are shown on Figure 1-1. The surveys were performed by Blackhawk Geosciences Division of Coleman Energy & Environmental Systems (CEES-BGD) for Lanai Water Company, Inc. (LWCI), an affiliate of Dole Food Company, Inc. from August 5 to August 19, 1994. Previous TDEM survey data taken during 1993 near the Manele Bay Hotel have been incorporated into this report.

Ground water resources occur on the Hawaiian Islands basically in two modes:

- in a basal mode where a lens of fresh water floats on saline water, and
- in a high-level mode where the ground water occurrence is controlled by damming structures.

These two modes of ground water occurrences are illustrated in Figure 1-2. Previous TDEM surveys on Lanai and other Hawaiian Islands have reliably mapped the boundary between fresh water in the basal mode and high-level occurrences. Normally, this main ground water boundary generally parallels the coastline in a volcanic setting. Water well production data from the Palawai Basin on Lanai has shown that other secondary damming structures exist above the main damming structure. Figure 1-3 shows a schematic geologic model that can help explain these two types of damming structures. Outlined in the figure is a major ring fracture developed from a caldera which is shown near parallel to the shoreline. Also shown are radial fractures which are shown to form near perpendicular to the major caldera ring fracture. Not shown are subsequent minor ring fractures which are postulated to occur within the major ring fracture. It is also postulated that the fracture areas are zones of weakness where intrusive dikes may preferentially form and these dikes can be impermeable. These radial fractures could be numerous and they could divide the high-level water into different compartments behind the major ring fractures. The resultant water production from a single compartment will be determined by several important factors which include permeability, porosity, size of and recharge to the compartment.

Based on the hydrologic information described above, the objectives for each of the three project areas are given in the following:

- determine if potential high-level ground water occurs throughout the Palawai Basin Project Area at locations above the approximate 1,000 ft (305 m) elevation level,
- determine the approximate inland position of the basal to high-level ground water boundary at the Windward Coast Project Area, and
- attempt to determine the boundary width of the expected rift zone at the Northwest Rift Project Area.

A ground water damming structure has been previously mapped by TDEM surveys above the Manele Bay Hotel and Golf Course. Drilling results indicate that basal mode water occurs at the approximate 200 ft (61 m) elevation level near the Manele Bay Hotel and that high-level water occurs near the approximate 1,150 ft (350 m) elevation level above the hotel. Furthermore, water well results within the Palawai Basin area indicate that secondary damming structures exist within the region above the main caldera ring damming structure.

LANAI NORTH, HAWAII
MAUI COUNTY

KALOHI CHANNEL

AUAU CHANNEL

WINDWARD COAST PROJECT AREA

NORTHWEST RIFT PROJECT AREA

TREND OF NORTHWEST RIFT ZONE

NWRZ1 NWRZ2 NWRZ3 NWRZ4 NWRZ5

LINE 1 LINE 2 LINE 3 LINE 4 LINE 5

L1S1 L1S2 L1S3 L1S4 L2S1 L2S2 L3S1 L4S1

PB1 PB2 PB3 PB4 PB5 PB6 PB7 PB8 PB9 PB10 PB11 PB12 PB13 PB14 PB15 PB16 PB17 PB18 PB19 PB20

LAHAINA DISTRICT

Lanai City

Lanaihale

Kaumalapau Light

APPROXIMATE LOCATION OF SOUTHWEST RIFT ZONE

APPROXIMATE LOCATION OF SOUTH RIFT ZONE

PALAWAI BASIN PROJECT AREA

PACIFIC OCEAN

NOTE: SEE ALL STREAMS INTERMITTENT

LEGEND

- PB 1 × — 1994 TRANSMITTER LOOP AND NUMBER
- 1993 DATA LOOP LOCATION
- WELL 10 (2107) — WELL NUMBER WITH HEAD IN FEET
- BRACKISH WATER PIPELINE (METAL)
- IRRIGATION PIPELINE (METAL)
- A — A' GEOELECTRIC CROSS SECTION

CEES BLACKHAWK GEOSCIENCES DIVISION

LOCATION MAP

LANAI WATER COMPANY, INC.
ISLAND OF LANAI, HAWAII

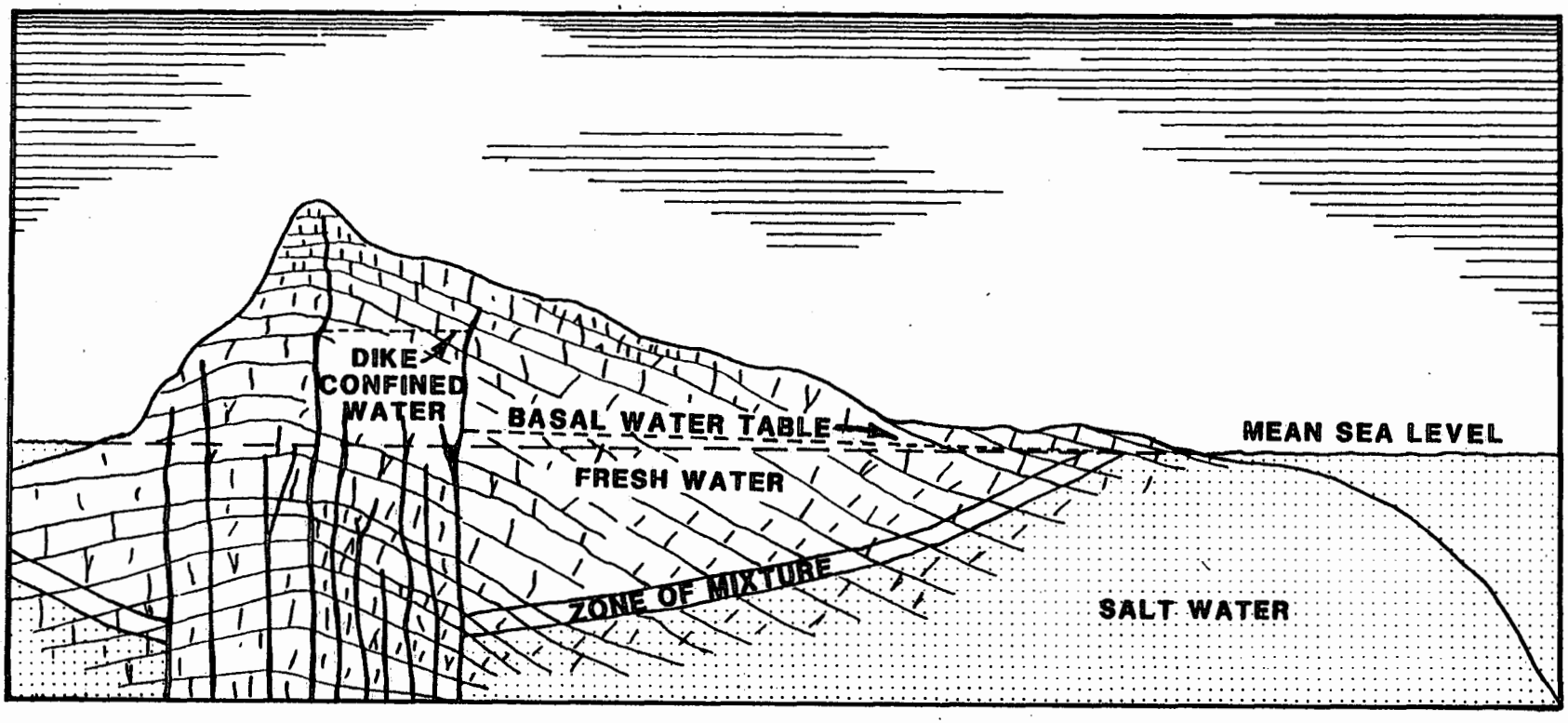
PROJECT NO. 9081-000 FIGURE 1-1

N

DECLINATION 11.5°

SCALE: 1" = 4000'

LANAI SOUTH, HAWAII
PROVISIONAL EDITION 1984
20156-F7-TM-025



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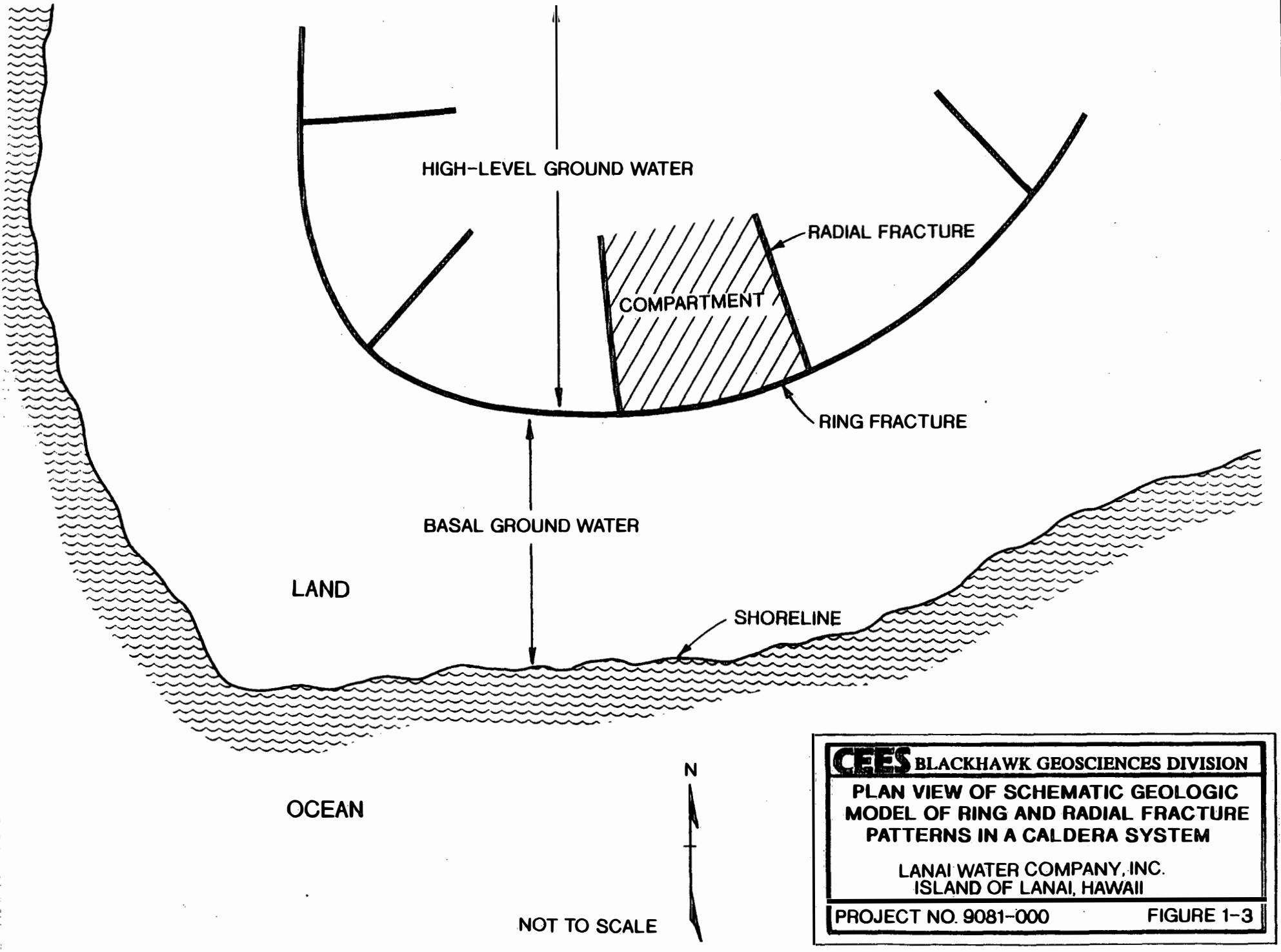
SCHEMATIC HYDROGEOLOGIC CROSS SECTION
LANAI WATER COMPANY, INC.
ISLAND OF LANAI, HAWAII

PROJECT NO. 9081-000 FIGURE 1-2



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PLAN VIEW OF SCHEMATIC GEOLOGIC MODEL OF RING AND RADIAL FRACTURE PATTERNS IN A CALDERA SYSTEM

LANAI WATER COMPANY, INC.
ISLAND OF LANAI, HAWAII

PROJECT NO. 9081-000 FIGURE 1-3

2.0 DATA ACQUISITION AND LOGISTICS

The TDEM surveys for the three project areas were performed by a three and sometimes four man crew, consisting of two CEES-BGD geophysicists and one to two field helpers provided by LWCI. The locations of the TDEM soundings and existing water wells for the three areas along with cultural features (e.g., buried pipelines) are shown on Figure 1-1. Sounding measurements were positioned in the Palawai Basin area to obtain optimum data coverage and were carefully located to avoid the existing power lines and pipelines which are known to affect TDEM data quality. A daily log of field activities for the three areas is given in Table 2-1. During the course of the survey, daily communication was made with either LWCI's representative or their consulting hydrogeologist to discuss the TDEM results and direction for the survey. A total of 35 soundings were taken at the three areas during the fifteen field days.

During the surveys, TDEM measurements were acquired using a central-loop sounding configuration. With this type of configuration, TDEM data are recorded with a receiver coil at the center of a square transmitter loop laid on the ground surface. The transmitter loops are constructed using 12-gauge insulated copper wire. The dimensions of the transmitter loops vary, depending upon the exploration depth required at each data site (larger loop dimensions are used for deeper exploration depth). Transmitter loop sizes varied from 750 ft by 750 ft to 1,500 ft by 1,500 ft throughout the three project areas. Sounding location and elevation control was based on compass and hip chain measurements from known landmarks (i.e., road junctions, drill holes). Periodic altimeter measurements and checks to known elevations from the field map were made several times each day.

The geophysical equipment utilized for the TDEM surveys was the Geonics EM37 system, which consists of a transmitter and receiver. A transmitter current between 10 and 25 amperes was used with base frequencies of 3 Hz and 30 Hz. At the center of each transmitter loop the time derivative of the vertical magnetic field was recorded with receiver coils with effective areas of 100 m^2 and 1,000 m^2. The field data from each sounding was stored in an Omnidata polycorder with solid state memory, and subsequently transferred to a PC-486 for nightly processing. A series of four additional offset (quality control) measurements symmetric about the loop center were also made at each sounding site to test for effects of inductive noise due to coupling with metallic features such as pipelines and power lines.

TDEM data quality was good due to efforts made in the field in positioning the soundings away from the potential cultural noise sources.

Table 2-1. Daily Log of Field Activities

Date (1994)	Activity
August 2 and 3	Pack and ship equipment from Golden, CO to Lanai City, HI.
August 4	Mobilize CEES-BGD crew from Golden, CO to Honolulu, HI. Meet with LWCI consulting hydrogeologist (T. Nance) to discuss the TDEM surveys on Lanai, HI.
August 5	Fly from Honolulu, HI to Lanai, HI. Meet LWCI representative at airport. Pick up geophysical equipment at airport and unpack and organize into field vehicle. Drive to LWCI office and meet with Mr. Bagoyo and discuss the TDEM surveys. Begin TDEM survey in the afternoon in the Palawai Basin Project Area. Acquire data on Sounding PB1. Mr. Murdock and Mr. Bagoyo make a visit to the field crew at 5 pm. Charge for half-day of field work.
August 6	Take data on Soundings PB2, PB3 and layout TX loop for PB4.
August 7	Acquire data on Soundings PB4, PB5 and PB6. Mr. Murdock makes a visit to the field crew at 5 pm.
August 8	Fax TDEM sounding data to Mr. Nance at 7 am. Read data on Soundings PB7, PB8 and PB9.
August 9	Meet with Mr. Murdock, Mr. Bagoyo and Mr. Nance to discuss the results from the TDEM survey data from Soundings PB1 through PB9. Also, discuss possible extension of scope of TDEM surveys to include other areas. Acquire data on Soundings PB10 and PB11.
August 10	Continue to take data at Palawai Basin on Soundings PB12, PB13 and PB14.
August 11	Discuss TDEM results with Mr. Bagoyo and Mr. Nance at 7 am. Read data on PB15 (Fairway 5 on Manele Golf Course), PB16 and PB17.
August 12	Take data along the South Rift Zone on Soundings PB18, PB19 and PB20. Decision is made by LWCI to extend the scope of the TDEM surveys to include four transects of data along the Windward Coast of Lanai from Keomuku Road to Halepalaoa Landing.
August 13	Start taking data on the Windward Coast of Lanai. Acquire data on Line 1 (above Halepalaoa Landing), Soundings 1, 2 and 3.
August 14	Acquire data on Line 2 (along Keomuku Road), Soundings 1, 2 and 3.
August 15	Read data on Line 3, Soundings 1 and 2.
August 16	Return to Line 1 and take data on Sounding 4 (above Puu Nene). Decision is made by LWCI to take a transect of data across the Northwest Rift Zone.

Table 2-1. (Continued)

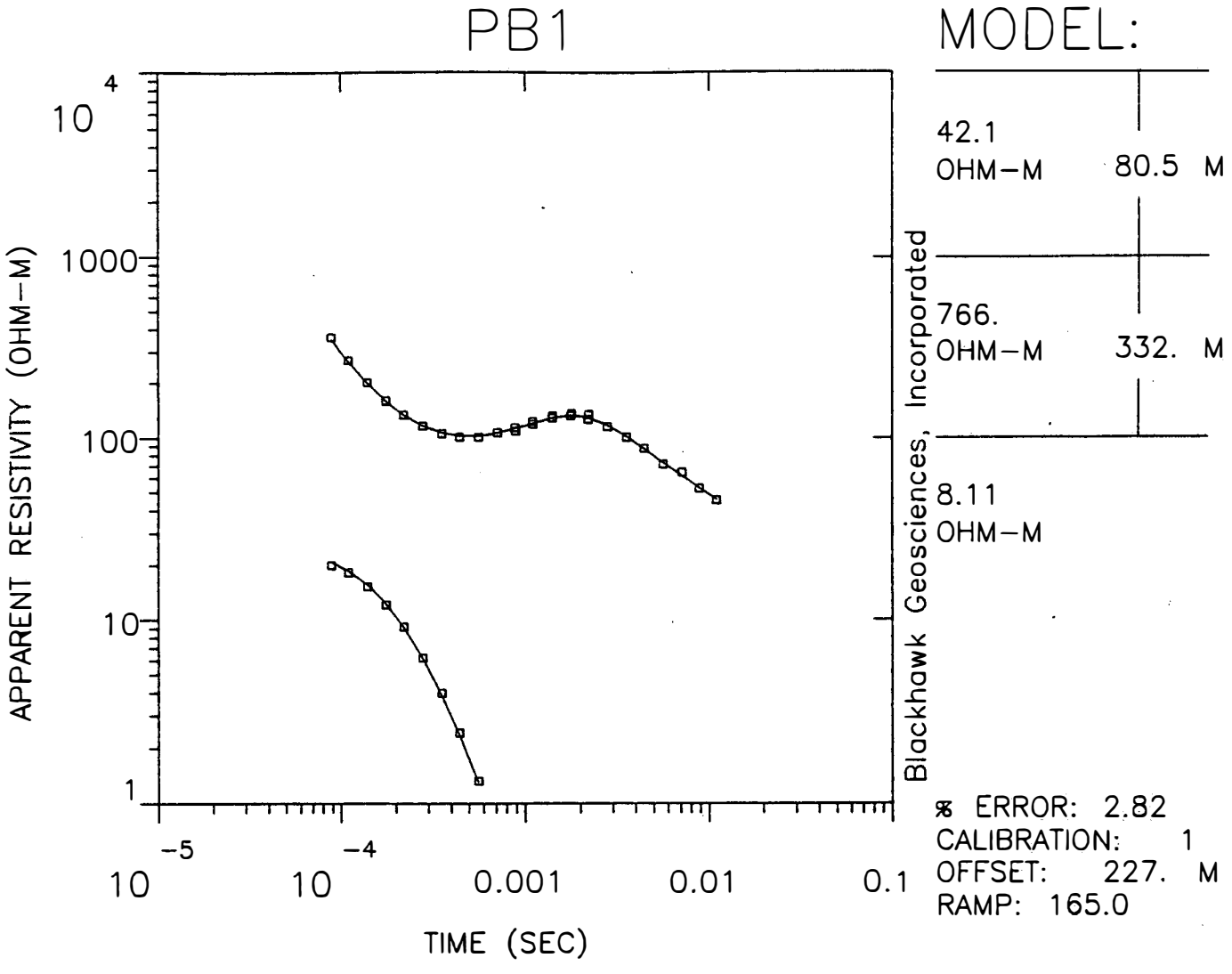
August 17	Acquire data on Line 4, Sounding 1. Finish Windward Coast Project. Move to Northwest Rift Project Area and read data on Line 5, Sounding 1 (NWRZ1).
August 18	Continue taking data on Line 5 (Northwest Rift), Soundings 2, 3 and 4.
August 19	Acquire data on Line 5, Sounding 5. Finish reading data at Northwest Rift Project Area at 1 pm. Pack up geophysical equipment and take to airport. Charge for half-day of field work. Demobilize a portion of equipment and J. Hild of CEES-BGD from Lanai, HI to Golden, CO.
August 20	Personal day off for R. Blohm of CEES-BGD.
August 21 and 22	Demobilize remaining portion of equipment that Hawaiian Airlines could not ship on previous flights. Demobilize remaining CEES-BGD crew from Lanai, HI to Golden, CO. (Includes tracking shipment through agricultural inspection in Honolulu).

3.0 DATA PROCESSING

The first step in processing TDEM data is to average the electromotive forces (emf's) recorded at opposite receiver polarities from the center of the sounding loop. Next, the recordings made at different amplifier gains and frequencies were combined to give one transient decay. The emf's of the selected time gates of the decay curves are subsequently entered into a ridge regression inversion program to obtain a one-dimensional (1-D) geoelectric section that matches the observed decay curve.

The inversion program requires an initial model input with resistivities and layers for the geoelectric section. This model is usually derived from approximate matching of apparent resistivity curves with model curves from a series of albums of model curves or from a knowledge of the geoelectric section obtained from the site geology and drill holes. The inversion program is then allowed to adjust the model to improve the fit. This involves the adjustment of resistivities and thicknesses of the layers within the geoelectric model. The inversion program does not change the total number of layers within the model but all other parameters float freely, or optionally can be held constant. To determine the influence of number of layers on the solution, separate inversions with a different number of layers are run.

An example of the output of the inversion program for Sounding PB1 is given in Figure 3-1. The measured data points (in terms of apparent resistivity) are superimposed on a solid line. The solid line represents the computed forward model for the geoelectric section shown on the right. This geoelectric section is the best match obtained by the inversion program. In Figure 3-2, the tabulated inversion parameters consisting of measured data, computed data for best match solution, and inversion error are given. The geoelectric section in turn is translated into hydrogeologic information by establishing a relationship between resistivity and hydrogeologic units. The principles of TDEM are explained in Appendix A. Inversion plots and tables for all of the 48 soundings from the 1993 and the present survey are given in Appendix B.



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EXAMPLE DATA SET SOUNDING PB1

LANAI WATER COMPANY, INC.
ISLAND OF LANAI, HAWAII

PROJECT NO. 9081-000 FIGURE 3-1

PB1

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		358.1	1175.0		
42.15	80.5	277.6	910.8	1.9	1.9
765.84	331.5	-53.9	-176.9	0.4	2.3
8.11					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	3.59E+02	3.50E+02	2.698	
2	1.10E-04	2.68E+02	2.64E+02	1.569	
3	1.40E-04	2.01E+02	1.99E+02	1.075	
4	1.77E-04	1.59E+02	1.58E+02	0.564	
5	2.20E-04	1.34E+02	1.34E+02	-0.097	
6	2.80E-04	1.16E+02	1.16E+02	-0.295	
7	3.55E-04	1.05E+02	1.07E+02	-1.679	
8	4.43E-04	1.01E+02	1.02E+02	-1.476	
9	5.64E-04	1.01E+02	1.02E+02	-1.237	
10	7.13E-04	1.07E+02	1.06E+02	0.849	
11	8.81E-04	1.13E+02	1.12E+02	1.238	
12	8.90E-04	1.09E+02	1.12E+02	-2.789	
13	1.10E-03	1.22E+02	1.20E+02	2.061	
14	1.10E-03	1.19E+02	1.20E+02	-0.882	
15	1.40E-03	1.29E+02	1.29E+02	0.141	
16	1.41E-03	1.32E+02	1.29E+02	2.230	
17	1.77E-03	1.33E+02	1.33E+02	-0.266	
18	1.80E-03	1.36E+02	1.33E+02	1.910	
19	2.20E-03	1.27E+02	1.30E+02	-2.289	
20	2.22E-03	1.34E+02	1.29E+02	3.602	
21	2.80E-03	1.15E+02	1.18E+02	-2.114	
22	3.55E-03	1.01E+02	1.02E+02	-1.485	
23	4.43E-03	8.74E+01	8.73E+01	0.062	
24	5.64E-03	7.14E+01	7.30E+01	-2.261	
25	7.13E-03	6.43E+01	6.15E+01	4.690	
26	8.81E-03	5.25E+01	5.29E+01	-0.737	
27	1.10E-02	4.53E+01	4.56E+01	-0.488	

R: 227. X: 0. Y: 228. DL: 455. REQ: 253. CF: 1.0000
CLHZ ARRAY, 27 DATA POINTS, RAMP: 165.0 MICROSEC, DATA: PB1
0508 PB 100WZ OPR XTL H 2 10+100
Ch.21 = 0.16 Ch.22 = 0.089 Ch.23 = 10.5 Ch.24 =
RMS LOG ERROR: 1.21E-02, ANTILOG YIELDS 2.8249 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

	P 1	P 2	P 3	T 1	T 2
P 1	0.98				
P 2	-0.01	0.03			
P 3	0.02	-0.04	0.80		
T 1	-0.03	-0.08	0.04	0.95	
T 2	0.00	0.04	0.01	0.01	1.00

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	38.652	42.149	45.805
	2	464.285	765.841	1600.172
	3	6.521	8.114	9.826
THICK	1	70.382	80.525	92.219
	2	318.602	331.527	343.899
DEPTH	1	70.382	80.525	92.219
	2	403.790	412.051	420.353

CEES BLACKHAWK GEOSCIENCES DIVISION

EXAMPLE DATA SET
SOUNDING PB1

LANAI WATER COMPANY, INC.
ISLAND OF LANAI, HAWAII

PROJECT NO. 9081-000 FIGURE 3-2

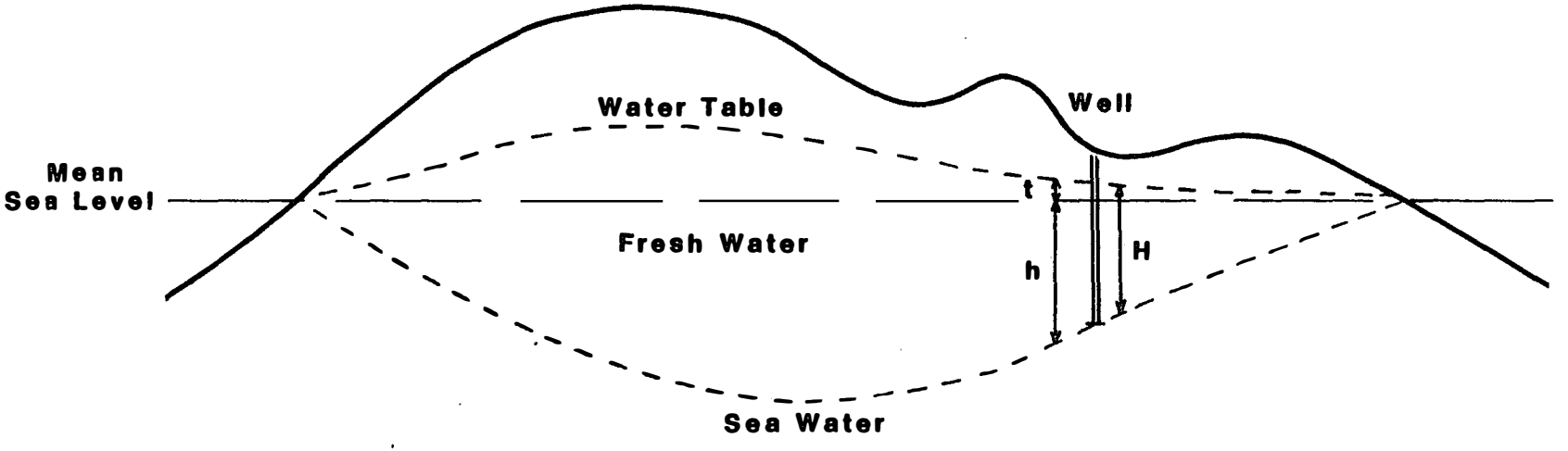
4.0 HYDROGEOLOGIC SETTING

General

Near the ocean around the Island of Lanai, ground water is expected to be contained in the basal mode, resting at sea level. This is mainly due to the fact that the volcanic rocks which comprise the island allow rainfall to percolate with little impedance directly downward through the island mass (Ref. Fig. 1-2). The fresh water is assumed to float upon the salt water which has encroached from the ocean. Fresh water flows laterally towards the ocean which causes the fresh water lens to be thinner towards the ocean. When ground water is under conditions of static equilibrium, the Ghyben-Herzberg Principle states that for every one foot of fresh water above sea level, approximately 40 ft of fresh water will exist below sea level. While at static equilibrium, the transition (zone of mixture) from fresh water to sea water is generally quite sharp. In Figure 4-1 the Ghyben-Herzberg Principle is illustrated. Further inland, the ground water is expected to be controlled by damming structures (e.g., dikes) and high-level ground water occurrences may result.

The Island of Lanai is geologically complex, with a collapsed caldera structure (Palawai Basin) being mapped in the southern central portion of the island (ref. Fig. 1-1). The southern rim of the caldera is expected to be located approximately parallel to the 1,200 ft (365 m) elevation level in the Palawai Basin Area, with numerous northwest-southeast trending dikes and faults being mapped away from the caldera feature (Stearns, 1936). Concentric patterns of dikes and faults are also postulated to emanate away from the collapsed caldera in the basin area. Wells 1, 9 and 10 are located within the expected rim of the Palawai Basin caldera. Well 10 is located at surface elevation 1,240 ft (378 m) and it is reported to have a static water level of 210 ft (head). The water in this well has a bottom hole temperature of 112°F at a depth of 225 ft below msl with 2800 ppm chlorides (per communication with T. Nance, 1994). Since this well is geothermally warm, it is expected to be located within a confining geologic structure associated with the southern rim of the caldera. Well 1, located in the northern portion of Palawai Basin at elevation 1265 ft (385 m), and Well 9 at elevation 1,395 ft (425 m), both exhibit extremely high static water levels, 818 ft and 812 ft head, respectively. The water at the bottom of these two wells is slightly geothermal (> 90°F) and they are expected to be located in separate confining geologic structures within the northern portion of the basin. The Manele Well, located at about 180 ft (55 m) elevation above the Manele Bay Hotel, has a reported 1.1 ft head and is a basal mode water occurrence. From the 1993 TDEM survey data in the Manele Bay Hotel area, it was mentioned that a ground water barrier is interpreted to exist between the Manele Well and Well 10 at the approximate 650 ft (205 m) elevation level. On the eastern side of the Palawai Basin a north-south trending rift zone is expected. Within rift zones, dikes of impermeable rocks can provide a barrier to ground water flow and this can result in high-level ground water and discontinuities in hydraulic gradients. Wells 12 and 13 are located within the South Rift Zone and show moderate fresh water static levels of 5 ft head. Recently, Well 12 has been used as a production well.

Along the Windward Coast of Lanai, the boundary between basal and high-level ground water is expected to occur further inland than in the Palawai Basin area. Ground water in this area is expected to be contained in the basal mode over a larger areal extent. Within the trend of the Northwest Rift Zone, faulting and diking is also expected to occur and barriers to ground water flow can produce compartments of high-level ground water in this area.



$t = 1/40\ (h)$

FROM: HERZBERG

CEES BLACKHAWK GEOSCIENCES DIVISION

Illustration of the
Ghyben-Herzberg Principle

LANAI WATER COMPANY, INC
ISLAND OF LANAI, HAWAII

PROJECT NO. 9081-000 FIGURE 4-1

5.0 RESULTS AND INTERPRETATION

General

The main objective of the TDEM soundings at the three project areas (Palawai Basin, Windward Coast and Northwest Rift) is to determine the subsurface resistivity layering (geoelectric section). A brief technical note describing the principles of TDEM is given in Appendix A. The translation of resistivity layering into hydrologic information is generally accomplished by two methods:

1. One method is to use available knowledge about the relation between resistivity values and local site hydrology. Using information from more than twenty-five previous TDEM surveys on the Hawaiian Islands, it has been observed that dry and fresh water saturated volcanics exhibit high resistivities, typically greater than 500 ohm-m. Conversely, volcanic rocks that are saturated with salt water exhibit resistivities typically less than 5 ohm-m. Weathered volcanics or ash flows and intrusives often exhibit intermediate resistivities (10 to 100 ohm-m). Using this knowledge, characteristic ranges of subsurface resistivities expected for local hydrogeologic units for the three project areas are shown in Figure 5-1. It should be recognized that some overlap in resistivities occur, but other factors are also used to infer the geologic/hydrologic formation in question. For example, a low resistivity unit (e.g., less than 10 ohm-m) occurring at an elevation above sea level is assumed to be caused by either intrusives or weathered rock formations rather than salt water saturated units.

2. Another method is to calibrate the geophysical interpretation at a well. At the Palawai Basin project area, four wells were available for comparison with the present TDEM survey interpretations. Well information was not available for comparison in the immediate vicinity of the Windward Coast or Northwest Rift Project areas.

Palawai Basin Project

During the TDEM surveys, a total of twenty sounding measurements were acquired in and around the Palawai Basin area. The Palawai Basin is located approximately 2.5 miles south of Lanai City and it encompasses an estimated area of about 6 square miles. The locations of the soundings taken during the present survey and the locations of the soundings from the 1993 survey near the Manele Bay Hotel have been incorporated into this data set and are shown on Figure 1-1. From the results of the TDEM interpretations, seven separate geoelectric cross sections were constructed. The orientation of each of the geoelectric sections is also shown on this figure.

Geoelectric Cross Section Line A-A'

Figure 5-2 shows the results of four TDEM soundings presented as a west to east trending geoelectric cross section (A-A') in which layers that exhibit similar resistivity values have been linked together. The cross section runs north of the airport towards Well 9 along the expected north edge of the Palawai Basin.

The upper layer of the cross section exhibits resistivities ranging from 13 to 49 ohm-m and is interpreted to represent the laterite soil across the basin. The laterite unit is expected to be approximately 290 ft thick beneath sounding PB4. The second layer in the section, below all soundings, displays high resistivities ranging from 219 to greater than 5000 ohm-m. This second layer is interpreted to represent dry unweathered volcanics above sea level and where it occurs below sea level it is expected to be saturated with fresh-brackish basal mode water. The lower layer beneath soundings PB4 and PB11 exhibits resistivities of 3.4 and 1.7 ohm-m, respectively. These resistivity values are interpreted to represent salt water saturated volcanics. The approximate thickness of the interpreted fresh-brackish water lens is 109 ft beneath Sounding PB4.

Sounding PB12 is interpreted to be located in the near vicinity of a ground water damming structure where a salt water interface is not interpreted and an intermediate resistivity value of 11 ohm-m is exhibited above and below sea level. The resistivity value of 11 ohm-m is expected to be caused by influence from lateral discontinuities (e.g., faults, dikes) or from altered volcanics. Because of the rapid lateral variation in resistivity (from PB4 to PB12) the interpreted resistivity stratification may not represent true formation resistivities. Sounding PB8 is expected to be located in a structurally complex area where a layer with an intermediate resistivity value of 23 ohm-m is interpreted to occur approximately 300 ft below msl. Well 9, which is slightly geothermal (> 90°C) and exhibits an extremely high static water level of 812 ft, is located approximately 3,500 ft northeast of Sounding PB8. Because this sounding is interpreted to be located within the postulated caldera rim, the interpreted resistivity value of 23 ohm-m may be influenced by lateral lithologic changes. In addition, alteration of the volcanics by geothermal waters may have decreased the bulk formation resistivity. Sounding PB8 is located above the inferred geologic/hydrologic structure, indicating the potential for high-level water in this vicinity. From the cross section, the exact location of the upper (inland) hydrologic boundary is difficult to determine. The TDEM data, however, would place the boundary midway between Soundings PB8 and PB12.

Geoelectric Cross-Section Line B-B'

The geoelectrical cross section for Line B-B' is shown in Figure 5-3. The cross section data starts in the Southwest Rift Zone and runs across the center of the Palawai Basin towards Well 1. The upper layer of the section is interpreted to represent the laterite soil with resistivity values ranging from 3.4 to 48 ohm-m. At Sounding PB6 a resistivity of 153 ohm-m is interpreted at the surface. The second layer in the cross section exhibits resistivities from 199 to 1009 ohm-m, and is interpreted to represent dry unweathered volcanics above sea level, and where it occurs below sea level it is expected to be saturated with fresh-brackish basal water. The lower layer beneath Sounding PB17 shows a resistivity value of 2.5 ohm-m and is interpreted to represent salt water saturated volcanics. The approximate thickness of the fresh-brackish water lens beneath PB17 is 206 ft.

Beneath Sounding PB3 a lower layer with a resistivity of 4.5 ohm-m is interpreted to occur both above and below sea level. This sounding is expected to be located in the vicinity of a ground water damming structure where the resistivity is expected to be influenced by lateral discontinuities and/or alteration of the volcanics by geothermal waters. Soundings PB2, PB6 and PB7 are located in a structurally complex area of the basin where the lower resistivity layer measured ranges from 19 to 23 ohm-m and the top of the layer occurs at depths from 625 ft to 1196 ft below msl. These soundings are interpreted to be located within the caldera rim and

Well 1 and 10 information (818 ft head, 210 ft head, respectively, and water temperatures > 90°F) suggests that even though a moderate resistivity layer is exhibited at depth, the potential for high-level water exists beneath these three soundings. From the TDEM results, the upper (inland) hydrogeologic boundary is placed between Soundings PB2 and PB3.

Geoelectric Cross-Section Line C-C'

Figure 5-4 shows the results for cross-section C-C' from Soundings PB1, PB2 and PB13. Laterite soil is interpreted as the upper layer for each sounding, with resistivities ranging from 32 to 48 ohm-m. The second layer of each sounding is interpreted to be dry unweathered volcanics above sea level and below sea level the volcanics are expected to be saturated with fresh-brackish water, with resistivities ranging from 199 to 1620 ohm-m. Below Sounding PB13, the third layer shows a resistivity of 4.5 ohm-m and salt water saturated volcanics are interpreted. The fresh-brackish water lens interpreted beneath Sounding PB13 has an approximate thickness of 74 ft.

Sounding PB1 is expected to be located in the vicinity of a ground water damming structure. Beneath this sounding a lower layer resistivity value of 8.1 ohm-m is interpreted to occur about 177 ft below msl. The resistivity stratification is expected to be influenced by lateral discontinuities and/or alteration of the volcanics by geothermal waters. Beneath Sounding PB2, a third layer resistivity value of 25 ohm-m is expected to occur about 625 ft below msl. This sounding is interpreted to be above the upper (inland) hydrogeologic boundary and the potential for high-level water is expected to exist in this area.

Geoelectric Cross-Section Line D-D'

The geoelectric cross section for Line D-D' is shown in Figure 5-5. A measurable layer of laterite soil is interpreted to occur in the section beneath Sounding PB2, but not at Soundings PB14 and PB16. The upper layer of the section exhibits high resistivity values which range from 120 ohm-m to greater than 5000 ohm-m. These high resistivity values are interpreted to be dry unweathered volcanics above sea level and below sea level the volcanics are expected to be saturated with fresh-brackish water. A thin basal water lens of 83 ft is expected beneath Sounding PB16. Sounding PB14 is interpreted to be located in the near vicinity of a ground water damming structure. This is because the second layer with a resistivity of 18 ohm-m is interpreted to occur near sea level. The existing TDEM results from these three soundings would place the upper (inland) hydrogeologic boundary between Soundings PB2 and PB14, with the potential for high-level water occurrence also above that boundary.

Geoelectric Cross-Section Line E-E'

Figure 5-6 shows the cross section for Line E-E'. A portion of the data (Line 2) used in constructing this cross section was acquired during a previous 1993 TDEM survey which was located downslope from the present survey. Along this section, data from two wells were available for comparison to help calibrate the geophysical interpretation. The location of Well 10 is about 2,000 ft south of Sounding PB5 and the location of Well 9 is approximately 3,500 ft northeast of Sounding PB8. The two wells show high static water levels (head) of 210 ft and 812 ft, respectively, with the horizontal distance between the two wells being approximately 16,000 linear ft. This large difference in heads over the three mile distance can be explained by geologic structures (faults or dikes) which are expected to occur throughout the Palawai Basin

Caldera. Soundings PB5, PB7, PB8 and PB9 show resistivity layers (from 5.6 to 23 ohm-m) occurring from about 313 ft to 1,260 ft below msl and are interpreted to lie in the caldera rim where geologic structures are expected. Sounding 3 is interpreted to be located in the near vicinity of a ground water damming structure. The TDEM results place the upper (inland) hydrogeologic boundary between Soundings 3 and 4 (Line 2, 1993 data).

Beneath Soundings 1, 2 and 5 the salt water interface is interpreted, and the approximate thickness of the fresh-brackish water lens is expected to be thin and only 20 ft beneath Sounding 5.

Geoelectric Cross-Section Line F-F'

The geoelectric cross section for Line F-F' is shown in Figure 5-7. The data for this cross section is combined from Line 1 of the 1993 data and the present TDEM surveys. Along this cross section, data from two wells were available for comparison to help calibrate the TDEM results. The Manele Well is located above the Manele Bay Hotel and is a basal mode water occurrence which shows a low static water level (head) of 1.1 ft. Well 1 is located about 3,000 ft north of Sounding PB6 and shows an extremely high static water level (head) of 818 ft. In the cross section beneath Soundings 1, 2 and 3, the salt water interface is detected and the approximate thickness of the fresh-brackish water lens is expected to be thickest (46 ft) beneath Sounding 2. Soundings 4 and 5 are interpreted to be located in the vicinity of the ground water damming structure. From the cross section, the location of the upper (inland) hydrogeologic boundary is interpreted between Soundings 5 and 6. Beneath Soundings 6, PB6 and PB20 intermediate resistivity values (from 11 to 19 ohm-m) are exhibited from about 340 ft to 1,000 ft below msl. These soundings are interpreted to be within the caldera rim where geologic structures are expected at depth, and where potential high-level ground water occurrence may result.

Geoelectric Cross-Section Line G-G'

The geoelectric cross section results for Line G-G' are shown in Figure 5-8. The soundings in this cross section are located in the approximate boundary of the South Rift Zone. Data from two wells were made available for comparison to help calibrate the geophysical results along this line. Well 12, which is located above sounding PB18 at an elevation of 605 ft, shows a basal mode water occurrence. The TDEM results from Sounding PB18 places the interpreted salt water interface at 173 ft below msl, and calculates to a head of about 4.3 ft when using the Ghyben-Herzberg Principle. These TDEM results are in good agreement with the reported head of 5 ft for Well 12. From the cross section, the exact location of the hydrogeologic damming structure is difficult to determine with the present TDEM data density. But, if the boundary trend from Line F-F' is extrapolated towards Line G-G', the TDEM information would place the boundary somewhere between Soundings PB18 and PB19. Soundings PB6, PB19 and PB20 exhibit similar intermediate resistivity values (11 to 22 ohm-m) below msl as Line F-F'. These soundings are interpreted to be within the caldera rim and geologic structures are expected to control the potential high-level ground water occurrence. This data is substantiated by the 818 ft head in Well 1.

Hydrogeologic Interpretations - Palawai Basin Project

The results of the TDEM soundings from the present Palawai Basin Project Area and the 1993 TDEM survey are further summarized in Table 5-1 and on the interpretation summary map shown in Figure 5-9. In Table 5-1 the thicknesses are listed of the fresh-brackish water lens calculated from the elevation of the salt water interface which is interpreted from the individual TDEM soundings. The table does not include the value of head calculated by using the Ghyben-Herzberg Principle. The TDEM soundings are separated into three main groups in Figure 5-9, and marked by a color code:

1. A group of 14 soundings (blue) beneath which a layer of low resistivity (< 5 ohm-m) was detected below sea level. A fresh-brackish water lens is expected to exist in the basal mode below these soundings. The approximate thickness of the lens floating on salt water is expected to vary from 2 ft at Sounding MBWELL-1 to 206 ft at Sounding PB17.

2. Soundings in which resistivities are influenced by lateral discontinuities and geologic/ hydrologic ground water damming structures are inferred (green). Intermediate resistivity values occur both above and below sea level in this area. Ground water levels, production and water quality are expected to be highly variable in these areas.

3. A group of soundings in which high resistivity values (> 200 ohm-m) are interpreted for an exploration depth interval that extends from about 300 ft (Sounding PB8) to 1,260 ft (Sounding PB9) below msl (yellow). This area is interpreted to be within the collapsed caldera rim and the potential for high-level water exists.

The accuracy of determining the location of the interpreted ground water damming structures at the Palawai Basin Project Area is mainly determined by TDEM data density (station spacing). Better definition of the lateral limits of the hydrogeologic boundary could be made with additional TDEM soundings. The upper (inland) hydrogeologic boundary is interpreted to vary in elevation across the Palawai Basin Project Area from about the 650 ft (200 m) level above the Manele Bay Hotel to about 1,300 ft (400 m) level near the airport.

A
WEST

A'
EAST

PB 11 | PB 4 | PB 12 | SOUNDING NUMBER | PB 8 | WELL 9 (OFFSET 3500' EAST)

KAUMALAPAU ROAD

GROUND SURFACE

1600
1200
800
400
0
-400
-800
-1200
-1600

ELEVATION (FEET)

104
13
31
49
37
531
219
991
>5000
1.7
3.4
11
23

HEAD = 812'

TD UNKNOWN

SEA LEVEL

SEA LEVEL

POSITION AND WIDTH OF DISCONTINUITY UNCERTAIN

MAXIMUM DEPTH OF EXPLORATION

BASAL MODE GROUND WATER

INFERRED GEOLOGIC/HYDROLOGIC GROUND WATER DAMMING STRUCTURE

POTENTIAL HIGH-LEVEL GROUND WATER

LEGEND

33 Resistivity in ohm-m

Laterite Soil

Dry Unweathered or Fresh-Brackish Water Saturated Volcanics

Inferred Structure (Possible Ash Flows, Weathered Volcanics or Intrusives)

Inferred Geologic/ Hydrologic Discontinuity

400 FT.

2000 FT.

0

CEES BLACKHAWK GEOSCIENCES DIVISION

GEOELECTRIC CROSS SECTION PALAWAI BASIN LINE A-A'

LANAI WATER COMPANY, INC.
ISLAND OF LANAI, HAWAII

PROJECT NO. 9081-000 FIGURE 5-2

B
SOUTHWEST

B'
NORTHEAST

SOUNDING NUMBER

PB 17 | PB 3 | PB 2 | PB 7 | PB 6

PUU ULAULA

MANELE ROAD

WELL 1 (OFFSET 3000' NORTH)

GROUND SURFACE

HEAD = 818'

TD - 3 FT

SEA LEVEL

POSITION AND WIDTH OF DISCONTINUITY UNCERTAIN

ELEVATION (FEET)

1400
1200
800
400
0
-400
-800
-1200
-1400

30
37
48
32
153
3.4
441
684
199
1009
234
2.5
4.5
25
23
19

BASAL MODE GROUND WATER

INFERRED GEOLOGIC/HYDROLOGIC GROUND WATER DAMMING STRUCTURE

MAXIMUM DEPTH OF EXPLORATION

POTENTIAL HIGH-LEVEL GROUND WATER

LEGEND

33 Resistivity in ohm-m

Laterite Soil

Dry Unweathered or Fresh-Brackish Water Saturated Volcanics

Inferred Structure (Possible Ash Flows, Weathered Volcanics or Intrusives)

Salt Water Saturated Volcanics

Inferred Geologic/Hydrologic Discontinuity

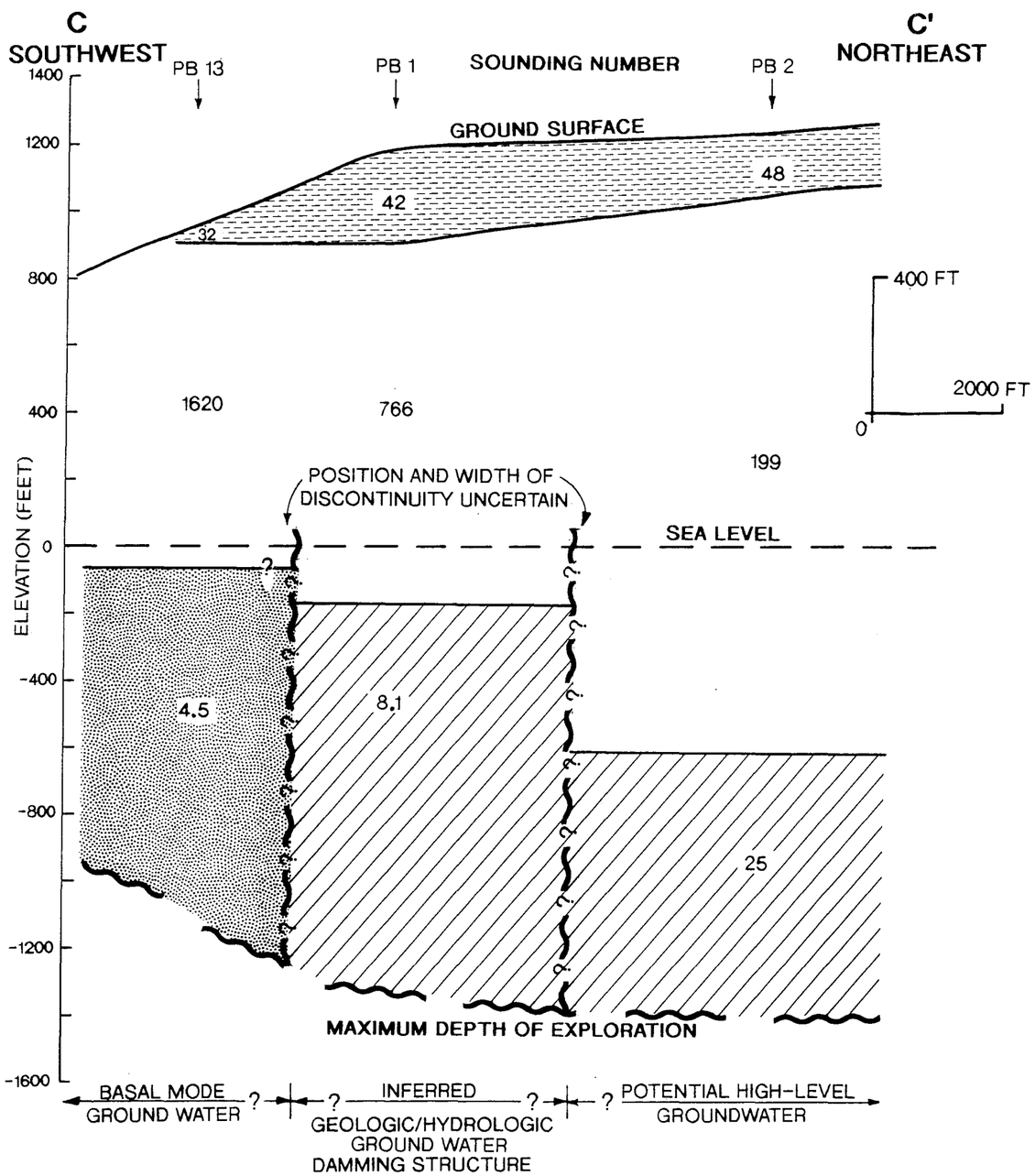
400 FT
2000 FT
0

CEES BLACKHAWK GEOSCIENCES DIVISION

GEOELECTRIC CROSS SECTION PALAWAI BASIN LINE B-B'

LANAI WATER COMPANY, INC.
ISLAND OF LANAI, HAWAII

PROJECT NO. 9081-000 FIGURE 5-3



LEGEND

33 Resistivity in ohm-m

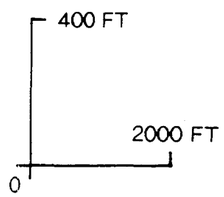
Laterite Soil

Dry Unweathered or Fresh-Brackish Water Saturated Volcanics

Inferred Structure (Possible Ash Flows, Weathered Volcanics or Intrusives)

Salt Water Saturated Volcanics

Inferred Geologic/Hydrologic Discontinuity

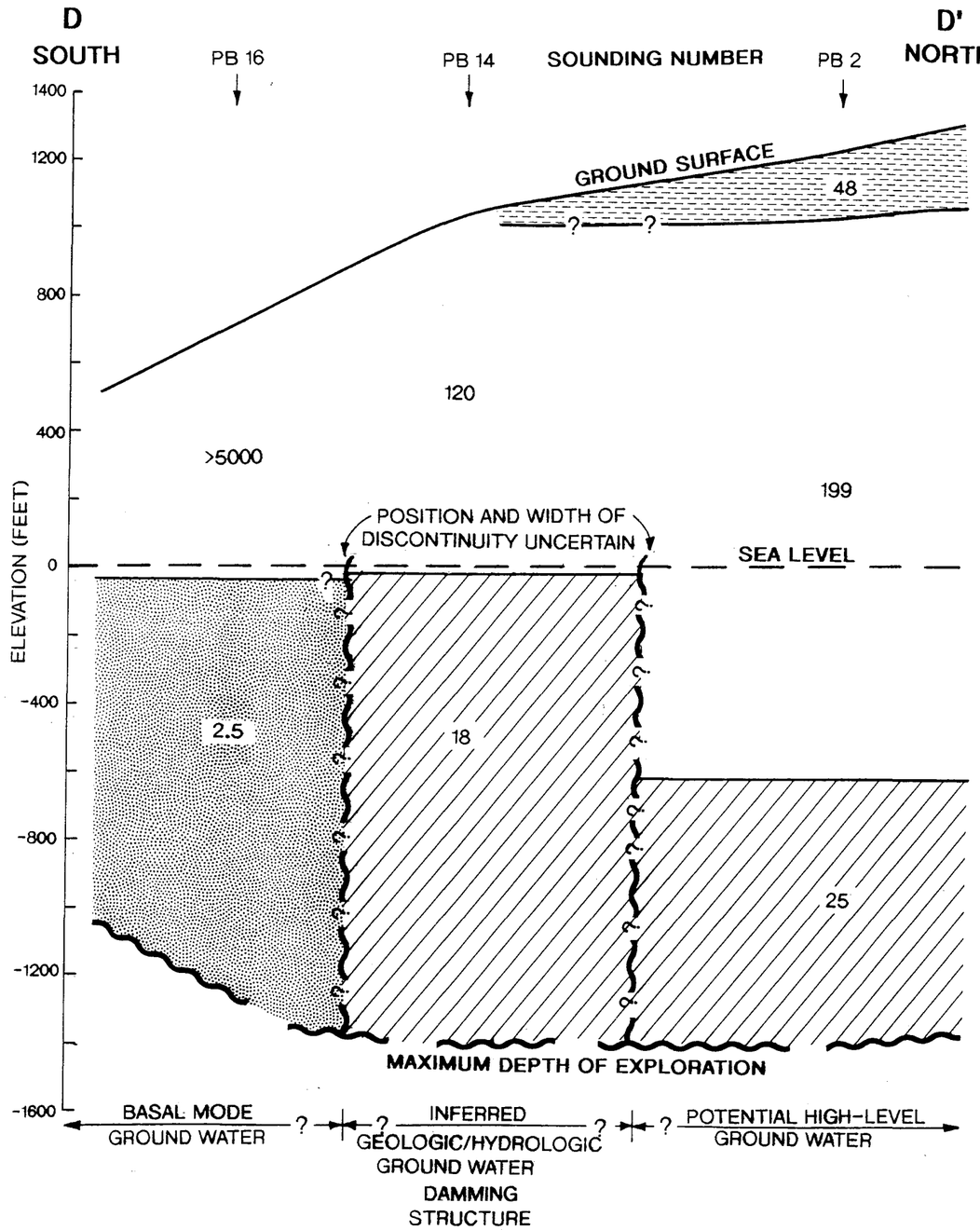


CEES BLACKHAWK GEOSCIENCES DIVISION

GEOELECTRIC CROSS SECTION PALAWAI BASIN LINE C-C'

LANAI WATER COMPANY, INC.
ISLAND OF LANAI, HAWAII

PROJECT NO. 9081-000 FIGURE 5-4



LEGEND

33 Resistivity in ohm-m

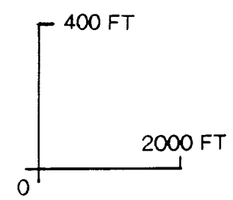
Laterite Soil

Dry Unweathered or Fresh-Brackish Water Saturated Volcanics

Inferred Structure (Possible Ash Flows, Weathered Volcanics or Intrusives)

Salt Water Saturated Volcanics

Inferred Geologic/Hydrologic Discontinuity



CEES BLACKHAWK GEOSCIENCES DIVISION

GEOELECTRIC CROSS SECTION PALAWAI BASIN LINE D-D'

LANAI WATER COMPANY, INC.
ISLAND OF LANAI, HAWAII

PROJECT NO. 9081-000 FIGURE 5-5

E

SOUTH

E'

NORTH

(LINE 2, 1993 DATA)

SOUNDING NUMBER

1 2 5 3 4 PB 5 PB 7 PB 9 PB 8

WELL 10 (OFFSET 800' WEST)

WELL 9 (OFFSET 3500' EAST)

GROUND SURFACE

GROUND SURFACE

HEAD = 210'

HEAD = 812'

TD-225'

TD UNKNOWN

POSITION AND WIDTH OF DISCONTINUITY UNCERTAIN

SEA LEVEL

SEA LEVEL

ELEVATION (FEET)

1600 1200 800 400 0 -400 -800 -1200

1931. 1657 250 1141 2874 238 243 143 218

122 39 51 32 25 37

3.8 2.8 3.4 6.3 5.6 23 47 23 13

MAXIMUM DEPTH OF EXPLORATION

BASAL MODE GROUND WATER

POTENTIAL HIGH-LEVEL GROUND WATER

INFERRED GEOLOGIC/HYDROLOGIC GROUND WATER DAMMING STRUCTURE

400 FT

2000 FT

0

LEGEND

33 Resistivity in ohm-m

Laterite Soil

Dry Unweathered or Fresh-Brackish Water Saturated Volcanics

Inferred Structure (Possible Ash Flows, Weathered Volcanics or Intrusives)

Salt Water Saturated Volcanics

Inferred Geologic/Hydrologic Discontinuity

CEES BLACKHAWK GEOSCIENCES DIVISION

GEOELECTRIC CROSS SECTION PALAWAI BASIN LINE E-E'

LANAI WATER COMPANY, INC.
ISLAND OF LANAI, HAWAII

PROJECT NO. 9081-000 FIGURE 5-6

F
SOUTH

F'
NORTH

(LINE 1 1993 DATA)

1 2 3 4 5 6

PB 20

PB 6

SOUNDING NUMBER

WELL 1 (OFFSET 3000' NORTH)

GROUND SURFACE

MANELE WELL

HEAD = 1.1'

HEAD = 818'

POSITION AND WIDTH OF DISCONTINUITY UNCERTAIN

SEA LEVEL

TD -3'

ELEVATION (FEET)

1600
1200
800
400
0
-400
-800
-1200
-1600

1400
1200
800
400
0
-400
-800
-1200
-1600

56
153
3 4
57
288
84
172
768
216
165
679
519
950
1009
1.8
1.8
2.9
9.0
29
260 ?
11
19

MAXIMUM DEPTH OF EXPLORATION

BASAL MODE GROUND WATER

INFERRED GEOLOGIC/HYDROLOGIC GROUND WATER DAMMING STRUCTURE

POTENTIAL HIGH-LEVEL GROUND WATER

LEGEND

33 Resistivity in ohm-m

Laterite Soil

Dry Unweathered or Fresh-Brackish Water Saturated Volcanics

Inferred Structure (Possible Ash Flows, Weathered Volcanics or Intrusives)

Salt Water Saturated Volcanics

Inferred Geologic/Hydrologic Discontinuity

400 FT

2000 FT

0

CEES BLACKHAWK GEOSCIENCES DIVISION

GEOELECTRIC CROSS SECTION PALAWAI BASIN LINE F-F'

LANAI WATER COMPANY, INC.
ISLAND OF LANAI, HAWAII

PROJECT NO. 9081-000 FIGURE 5-7

G
SOUTH

G'
NORTH

PB 18 | PB 19 | PB 20 | PB 6 | SOUNDING NUMBER

PUU MAHANALUA

WELL 1 (OFFSET 3000' NORTH)

GROUND SURFACE

39 | 56 | 153 | 3.4

HEAD = 818'

WELL 12

25

216

BOUNDARY EXTRAPOLATED FROM 1993 LINE 1 DATA
POSITION AND WIDTH OF DISCONTINUITY UNCERTAIN

603 | 677 | 1009

HEAD = 5'
TD - 15'

SEA LEVEL

TD -3'

3.2

11

22

19

MAXIMUM DEPTH OF EXPLORATION

ELEVATION (FEET)

1600 | 1200 | 800 | 400 | 0 | -400 | -800 | -1200 | -1600

BASAL MODE GROUND WATER

INFERRED GEOLOGIC/HYDROLOGIC GROUND WATER DAMMING STRUCTURE

POTENTIAL HIGH-LEVEL GROUND WATER

LEGEND

33 — Resistivity in ohm-m

Laterite Soil

Dry Unweathered or Fresh-Brackish Water Saturated Volcanics

Inferred Structure (Possible Ash Flows, Weathered Volcanics or Intrusives)

Salt Water Saturated Volcanics

Inferred Geologic/Hydrologic Discontinuity

400 FT

2000 FT

0

CEES BLACKHAWK GEOSCIENCES DIVISION

GEOELECTRIC CROSS SECTION PALAWAI BASIN LINE G-G'

LANAI WATER COMPANY, INC.
ISLAND OF LANAI, HAWAII

PROJECT NO. 9081-000 FIGURE 5-8

LANAI NORTH, HAWAII
MAUI COUNTY

KALOHI CHANNEL

AUAU CHANNEL

PACIFIC OCEAN

WINDWARD COAST PROJECT AREA

NORTHWEST RIFT PROJECT AREA

PALAWAI BASIN PROJECT AREA

TREND OF NORTHWEST RIFT ZONE

APPROXIMATE LOCATION OF SOUTHWEST RIFT ZONE

APPROXIMATE LOCATION OF SOUTH RIFT ZONE

LAHAINA DISTRICT

NOTE: ALL STREAMS INTERMITTENT

NOTE
① USGS BM 17M 1923 - 55 1
② BM. HAWAIIAN TERR SURVEY - 4 4
③ TIDAL BM #5 - 10 0
④ TIDAL BM #2 1927 - 5 5

LEGEND

-40 APPROXIMATE ELEVATION OF TOP OF SALT WATER INTERFACE IN FEET

SOUNDING IN WHICH GROUND WATER IS EXPECTED IN THE BASAL MODE

SOUNDING INTERPRETED TO BE LOCATED WITHIN THE GROUND WATER BARRIER (ZONE OF CHANGE)

SOUNDING IN WHICH GROUND WATER IS EXPECTED TO BE CONTROLLED BY GEOLOGIC STRUCTURE (POTENTIAL HIGH-LEVEL WATER)

INFERRED GEOLOGIC/HYDROLOGIC DISCONTINUITY (POSITION AND WIDTH UNCERTAIN)

PB 1 — 1994 TRANSMITTER LOOP AND NUMBER

1993 DATA LOOP LOCATION

WELL 10 (210') — WELL NUMBER WITH HEAD IN FEET

BRACKISH WATER PIPELINE (METAL)

IRRIGATION PIPELINE (METAL)

A A' GEOELECTRIC CROSS SECTION

CEES BLACKHAWK GEOSCIENCES DIVISION

GEOPHYSICAL INTERPRETATION SUMMARY MAP
LANAI WATER COMPANY, INC.
ISLAND OF LANAI, HAWAII

PROJECT NO. 9081-000 FIGURE 5-9

SCALE: 1" = 4000'

CONTOUR INTERVAL 10 METERS

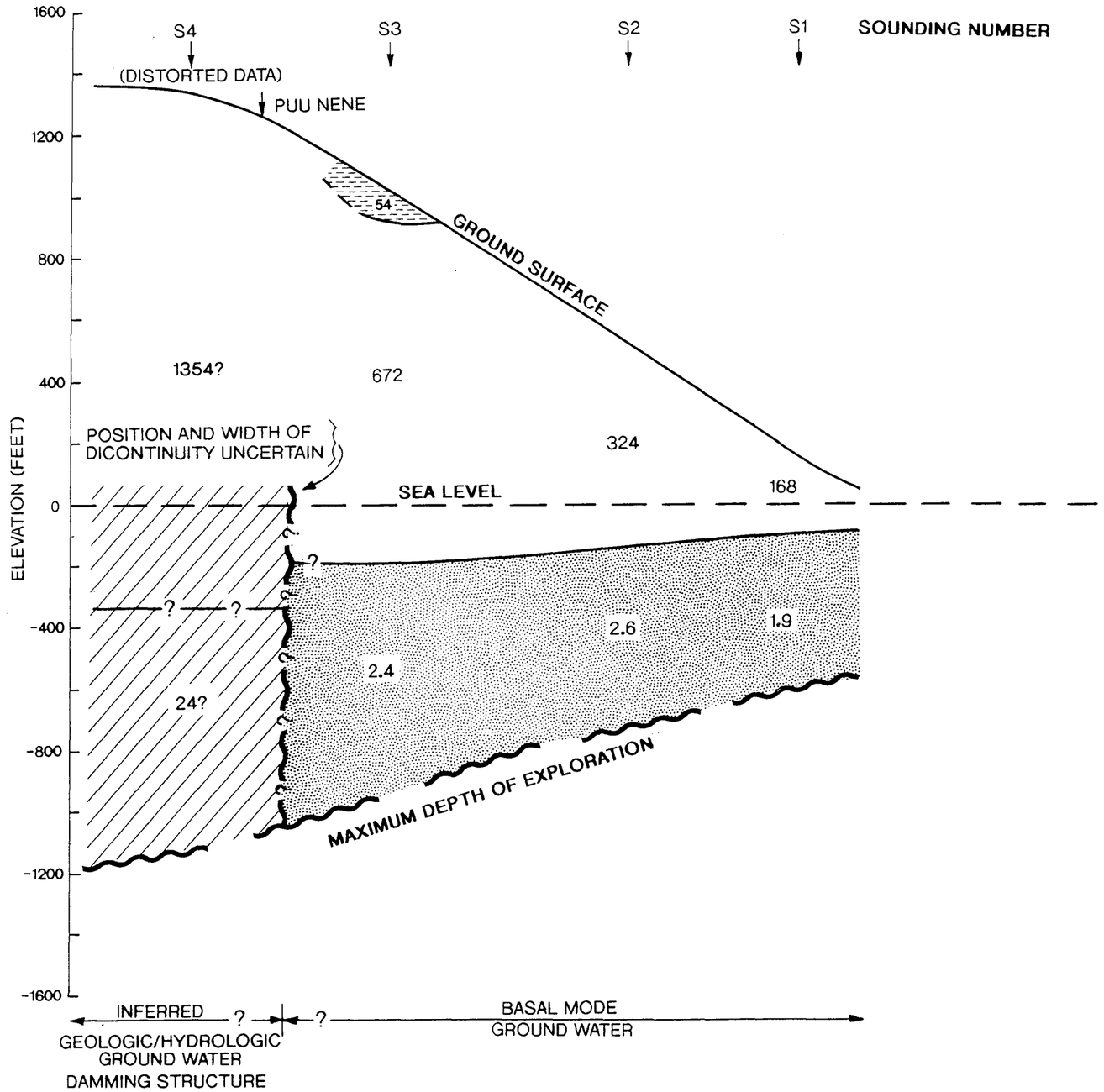
DECLINATION 11.5°

LANAI SOUTH, HAWAII
PROVISIONAL EDITION 1984
20156-F7-TM-025

SOUTHWEST

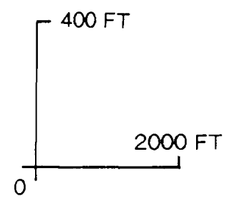
LINE 1

NORTHEAST



LEGEND

- 33 — Resistivity in ohm-m
- Laterite Soil
- Dry Unweathered or Fresh-Brackish Water Saturated Volcanics
- Inferred Structure (Possible Ash Flows, Weathered Volcanics or Intrusives)
- Salt Water Saturated Volcanics
- ? — Inferred Geologic/Hydrologic Discontinuity



CEES BLACKHAWK GEOSCIENCES DIVISION

GEOELECTRIC CROSS SECTION
WINDWARD COAST LINE 1
LANAI WATER COMPANY, INC.
ISLAND OF LANAI, HAWAII

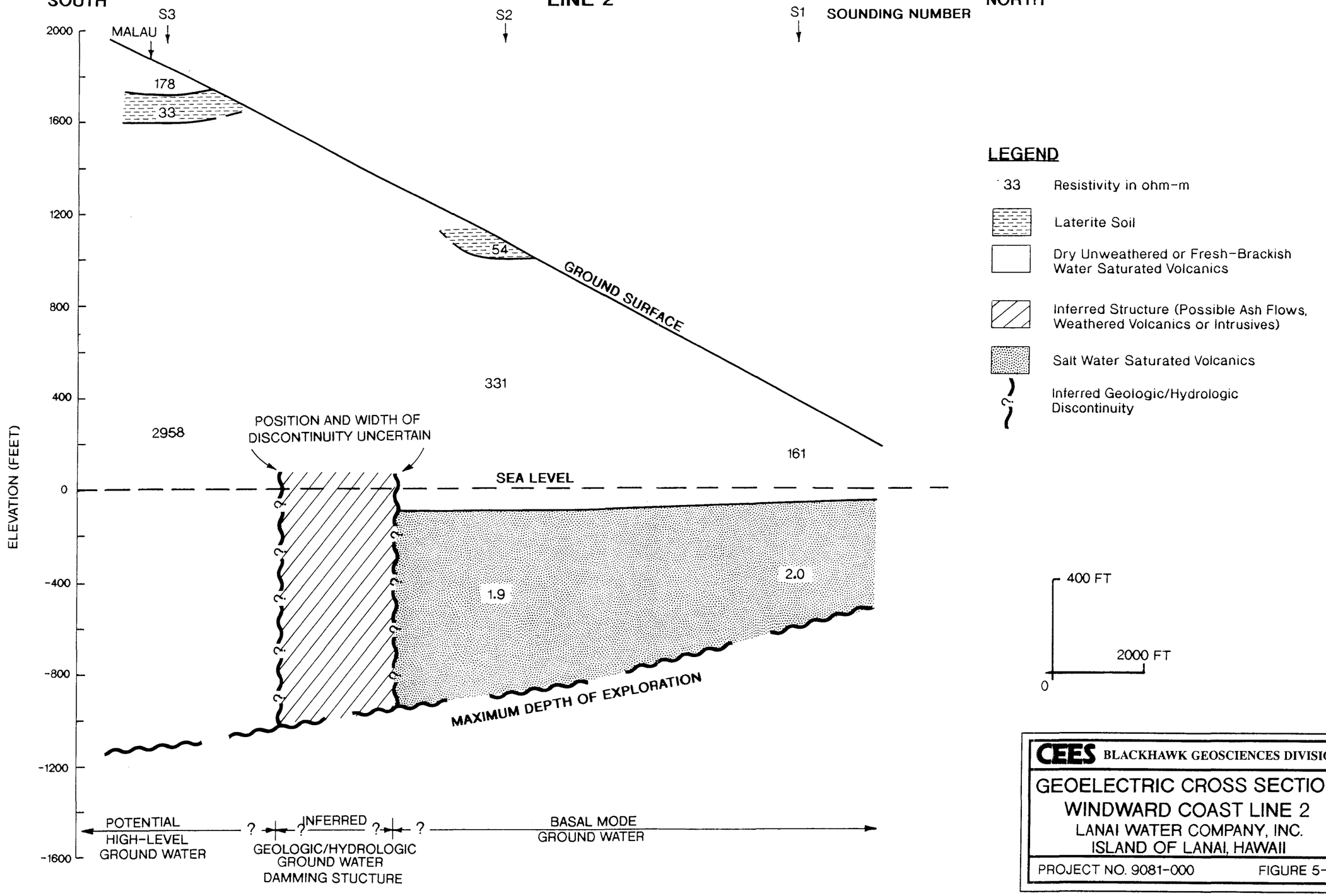
PROJECT NO. 9081-000 FIGURE 5-10

LINE 2

SOUTH

NORTH

SOUNDING NUMBER



LEGEND

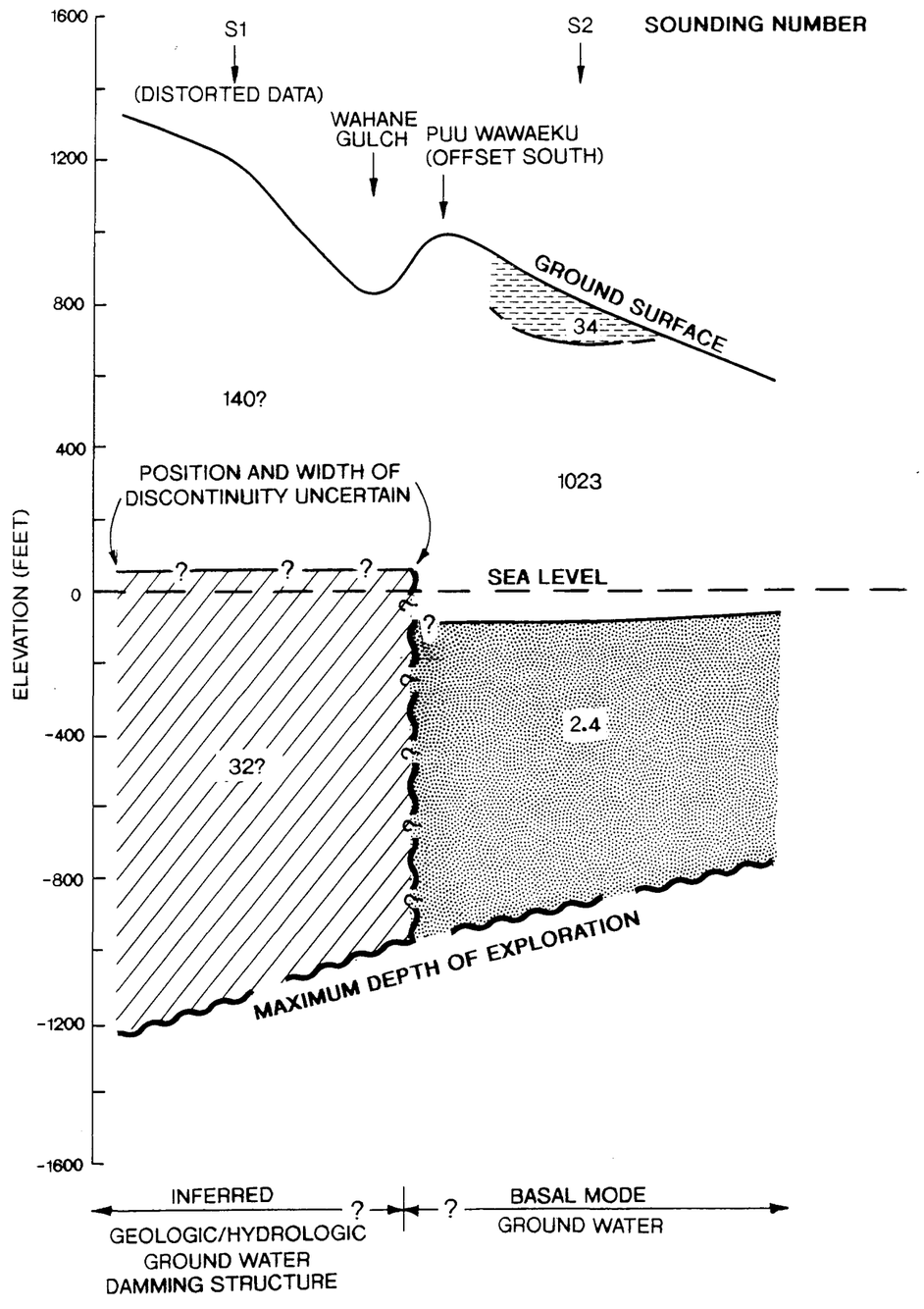
- 33 — Resistivity in ohm-m
- Laterite Soil
- Dry Unweathered or Fresh-Brackish Water Saturated Volcanics
- Inferred Structure (Possible Ash Flows, Weathered Volcanics or Intrusives)
- Salt Water Saturated Volcanics
- Inferred Geologic/Hydrologic Discontinuity

CEES BLACKHAWK GEOSCIENCES DIVISION

GEOELECTRIC CROSS SECTION
WINDWARD COAST LINE 2
LANAI WATER COMPANY, INC.
ISLAND OF LANAI, HAWAII

PROJECT NO. 9081-000 FIGURE 5-11

SOUTHWEST **LINE 3** NORTHEAST



LEGEND

33 Resistivity in ohm-m

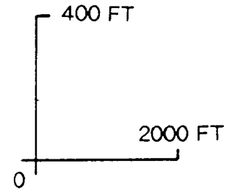
Laterite Soil

Dry Unweathered or Fresh-Brackish Water Saturated Volcanics

Inferred Structure (Possible Ash Flows, Weathered Volcanics or Intrusives)

Salt Water Saturated Volcanics

Inferred Geologic/Hydrologic Discontinuity



CEES BLACKHAWK GEOSCIENCES DIVISION

GEOELECTRIC CROSS SECTION
WINDWARD COAST LINE 3
LANAI WATER COMPANY, INC.
ISLAND OF LANAI, HAWAII

PROJECT NO. 9081-000 FIGURE 5-12

LINE 5

SOUTH

NORTH

SOUNDING NUMBER

NWRZ3 NWRZ2 NWRZ1 NWRZ4 NWRZ5

ELEVATION (FEET)

1600
1200
800
400
0
-400
-800
-1200

GROUND SURFACE

343 >5000 538 250 2498

POSITION AND WIDTH OF DISCONTINUITY UNCERTAIN

POSITION AND WIDTH OF DISCONTINUITY UNCERTAIN

SEA LEVEL

319 7 60 66 53

4.7 16 33 4.5 2.6

MAXIMUM DEPTH OF EXPLORATION

BASAL MODE GROUND WATER

INFERRED GEOLOGIC/HYDROLOGIC GROUND WATER DAMMING STRUCTURE

POTENTIAL HIGH-LEVEL GROUND WATER

INFERRED GEOLOGIC/HYDROLOGIC GROUND WATER DAMMING STRUCTURE

BASAL MODE GROUND WATER

LEGEND

33 Resistivity in ohm-m

Laterite Soil

Dry Unweathered or Fresh-Brackish Water Saturated Volcanics

Inferred Structure (Possible Ash Flows, Weathered Volcanics or Intrusives)

Salt Water Saturated Volcanics

Inferred Geologic/ Hydrologic Discontinuity

400 FT

2000 FT

0

CEES BLACKHAWK GEOSCIENCES DIVISION

GEOELECTRIC CROSS SECTION
NORTHWEST RIFT LINE 5
LANAI WATER COMPANY, INC.
ISLAND OF LANAI, HAWAII

PROJECT NO. 9081-000 FIGURE 5-14

Table 5-1

Hydrogeologic Information Derived From TDEM Soundings for Palawai Basin Project

Sounding #	Surface Elev. (ft)	(m)	Approx. Thickness of Fresh-Brackish Water Lens (ft)	Comments
1994: PB1	1175	358	Ground Water Barrier	
PB2	1227	374	Structure Controlled	
PB3	1283	391	Ground Water Barrier	Southwest Rift Zone
PB4	1194	364	Basal Mode Water (110)	
PB5	1194	364	Structure Controlled	Near Well 10 (210') Head
PB6	1188	362	Structure Controlled	Near Well 1 (818') Head
PB7	1099	335	Structure Controlled	
PB8	1286	392	Structure Controlled	Near Well 9 (812') Head
PB9	1119	341	Structure Controlled	
PB10	1503	458	Ground Water Barrier	Near Puu Koa
PB11	853	260	Basal Mode Water (98)	
PB12	1371	418	Ground Water Barrier	
PB13	948	289	Basal Mode Water (74)	
PB14	1047	319	Ground Water Barrier	
PB15	360	110	Basal Mode Water (37)	On Manele Bay Golf Course, Hole 5
PB16	702	214	Basal Mode Water (83)	
PB17	1152	351	Basal Mode Water (206)	Southwest Rift Zone
PB18	554	169	Basal Model Water (173)	South Rift Zone, near Well 12 (5') Head
PB19	1309	399	Structure Controlled	South Rift Zone
PB20	1237	377	Structure Controlled	South Rift Zone
1993: L1S1	246	75	Basal Mode Water (40)	Along Manele Road
L1S2	394	120	Basal Mode Water (46)	Along Manele Road
L1S3	508	155	Basal Mode Water (36)	Along Manele Road
L1S4	720	219	Ground Water Barrier	Along Manele Road

Table 5-1 (Continued)

L1S5	886	270	Ground Water Barrier	Along Manele Road
L1S6	1198	365	Structure Controlled	
L2S1	377	115	Basal Mode Water (11)	
L2S2	475	145	Basal Mode Water (10)	
L2S3	574	175	Ground Water Barrier	
L2S4	836	255	Structure Controlled	
L2S5	558	170	Basal Mode Water (20)	
MBWELL-1	196	60	Basal Mode Water (2)	At Manele Well 1
L3S1	492	150	Ground Water Barrier	
L3S2	810	247	Structure Controlled	

Windward Coast Project

The area designated as the Windward Coast Project runs roughly from Keomuku Road on the west to Halepalaoa Landing (Club Lanai) on the east. The location of the ten TDEM soundings acquired on the project area are shown in Figure 1-1. The results from the TDEM interpretations are presented as four geoelectric cross sections.

Geoelectric Cross-Section Line 1

Figure 5-10 shows the results of four soundings taken above the Halepalaoa Landing Area. Beneath Soundings L1S1, L1S2 and L1S3 the salt water interface is interpreted and the approximate thickness of the fresh-brackish water lens is expected to be 91 ft beneath Sounding L1S1 and 188 ft beneath Sounding L1S3. Sounding L1S4 shows a distorted data response which is most likely due to the influence of vertical structures (e.g., dikes) in the near vicinity of the sounding measurements. The sounding was located above Puu Nene and all four offset (quality control) measurements taken within the sounding were shown to be distorted and cultural features (e.g., pipelines, power lines) are not the expected cause of the distorted response. The interpretation of the data in the near vicinity of such vertical structures will be in error because the inversion routines use horizontal one-dimensional (1-D) models, and vertical structures are non 1-D. Therefore, the resistivity layering and values are questionable. Also because of the distorted response at L1S4, the location of the lower (seaward) hydrogeologic boundary is difficult to position, but is most likely located between L1S3 and L1S4. An estimate of the upper (inland) boundary cannot be made.

Geoelectric Cross-Section Line 2

Three soundings were taken along Keomuku Road and the cross section for Line 2 is shown in Figure 5-11. The salt water interface is interpreted beneath soundings L2S1 and L2S2, and the thickness of the fresh-brackish water lens is expected to be approximately 61 ft below Sounding L2S1 and 96 ft beneath Sounding L2S2. Below Sounding L2S3 a layer with a resistivity of less than 5 ohm-m was not observed within the effective exploration depth of about

1,000 ft below msl, and therefore neither salt water saturated volcanics or structures are inferred. Because Sounding L2S3 is located above the interpreted geologic/hydrologic structure, there is potential for high-level water in this vicinity. From the cross section, the exact location of the upper and lower hydrogeologic boundaries are difficult to determine with the existing data density, but boundary would be expected somewhere between Soundings L2S2 and L2S3.

Geoelectric Cross-Section Line 3

Figure 5-12 displays the results for cross-section Line 3 from Soundings L3S1 and L3S2. Beneath Sounding L3S2 the salt water interface is interpreted and the approximate thickness of the fresh-brackish water lens is expected to be 85 ft. Sounding L3S1 shows a distorted data response which is interpreted to be influenced by vertical structures in the vicinity of the measurement. The sounding was located above Puu Wawaeku and between Maunalei Gulch and Wahawe Gulch, and faulting and diking in this area is expected and is most likely the cause of the distorted response rather than cultural features. Because the interpretation of the data at this sounding is questioned, the resistivity values and layering is questioned in the geoelectric section. From the TDEM data, an estimate of the location of the lower (seaward) hydrogeologic boundary is placed between the two soundings.

Geoelectric Cross-Section Line 4

On Figure 5-13 the geoelectric section for the one sounding acquired on Line 4 is shown. The upper layer of the section exhibits a resistivity value of 3363 ohm-m, which is interpreted to represent dry unweathered volcanics above sea level and where it occurs below sea level it is expected to be saturated with fresh-brackish basal mode water. The lower layer exhibits a resistivity of 4.8 ohm-m and it is interpreted to represent salt water saturated volcanics. The approximate thickness of the fresh-brackish water lens is 171 ft beneath Sounding L4S1. Due to the limited road access in this area sounding data could not be taken above this location.

Hydrogeologic Interpretations - Windward Coast Project

Table 5-2 lists the results of the TDEM soundings from the Windward Coast Project Area. The thicknesses of the fresh-brackish water lens is calculated from the elevation of the salt water interface interpreted from the TDEM soundings. The table does not include the value of head calculated from the Ghyben-Herzberg Principle.

This information is further summarized on the interpretation summary map shown on Figure 5-9. The soundings are separated into three main groups and marked by a color code:

1. Seven soundings (blue) beneath which a layer of low resistivity (less than 5 ohm-m) was detected below sea level. A fresh-brackish water lens is expected to exist in the basal mode below these soundings. The approximate thickness of the lens floating on salt water is expected to be largest at L1S3 with 188 ft.

2. Two soundings (L1S4 and L3S1) which show distorted data responses where the data is interpreted to be influenced by vertical structures (e.g., faults, dikes) in the vicinity of the measurement (green). The geologic/hydrologic ground water damming boundary is inferred below these soundings.

3. One sounding (L2S3) in which high resistivity values are interpreted to the maximum exploration depth of about 1,000 ft below msl (yellow). In this area the potential for high-level water is expected.

At the Windward Coast Project Area, the accuracy of determining the position of the interpreted ground water damming structures is mainly determined by the limited data density in this area. Due to the limited road access to this side of the island, it may be difficult to better define the lateral extent of the hydrogeologic boundaries. But if further TDEM surveys are required in this area, access to remote sites like this have been accomplished by helicopter support on other Hawaiian islands.

Table 5-2

Hydrogeologic Information Derived From TDEM Soundings for Windward Coast Project

Line/Sounding #	Surface Elev. (ft)	Surface Elev. (m)	Approx. Thickness of Fresh-Brackish Water Lens (ft)	Comments
Line 1/ NSL1S1	180	55	Basal Mode Water (91)	
NSL1S2	528	161	Basal Mode Water (115)	
NSL1S3	1024	312	Basal Mode Water (188)	
NSL1S4	1329	405	Ground Water Barrier*	Above Puu Nene
Line 2/ NSL2S1	387	118	Basal Mode Water (62)	Along Keomuku Road
NSL2S2	1066	325	Basal Mode Water (96)	Along Keomuku Road
NSL2S3	1821	555	Structure Controlled	Along Keomuku Road
Line 3/ NSL3S1	1201	366	Ground Water Barrier*	Above Maunalei Gulch
NSL3S2	804	245	Basal Mode Water (85)	Below Wawaeku
Line 4/ NSL4S1	1115	340	Basal Mode Water (171)	

*Distorted data.

Northwest Rift Project Area

The Northwest Rift Project Area is located about 4 miles northwest of Lanai City as shown on Figure 1-1. At this area five soundings were taken in a south-north trending transect across the expected trend of the rift zone.

Geoelectric Cross Section Line 5

Figure 5-14 shows the results of the geoelectric cross section from Line 5. Beneath Soundings NWRZ3, 4 and 5 the lower layer exhibits resistivity values ranging from 2.6 to 4.7 ohm-m, which is interpreted to represent salt water saturated volcanics. The upper layer in the cross section, with resistivities from 343 ohm-m to 2498 ohm-m, is interpreted to represent dry unweathered volcanics above sea level and where it occurs below sea level it is expected to be saturated with fresh-brackish basal mode water. The approximate thickness of the fresh-brackish water lens is expected to be greatest (292 ft) beneath Sounding NWRZ4.

Beneath Soundings NWRZ1 and NWRZ2 a salt water interface is not interpreted. Instead, intermediate resistivity values (16 to 33 ohm-m) are exhibited from 740 ft to 780 ft below msl. Because of the rapid lateral variation in resistivity between Soundings NWRZ1 to NWRZ4 and NWRZ2 to NWRZ3, lateral discontinuities (e.g., faults, dikes) are expected to occur between these two sets of soundings. From the cross section, the exact location of the hydrogeologic boundary is placed somewhere between Sounding NWRZ1 and NWRZ4 on the north side and between NWRZ2 and NWRZ3 on the south side. Since the salt water interface was not interpreted beneath NWRZ1 and NWRZ2, the elevation of the water table cannot be estimated. Because these two soundings are interpreted to be located above the interpreted geologic/hydrologic structure, the potential for high-level water is expected in this vicinity.

Hydrogeologic Interpretations - Northwest Rift Project

The results of the five TDEM soundings from the Northwest Rift Project Area are listed in Table 5-3. The thicknesses of the fresh-brackish water lens is calculated from the elevation of the salt water interface interpreted from the TDEM soundings. The table results do not include the value of head calculated from the Ghyben-Herzberg Principle.

Table 5-3

Hydrogeologic Information Derived From TDEM Soundings for Northwest Rift Project

Line/Sounding #	Surface Elev. (ft)	Surface Elev. (m)	Approx. Thickness of Fresh-Brackish Water Lens (ft)	Comments
Line 5/ NWRZ1	1667	508	Structure Controlled	Northwest Rift Zone
NWRZ2	1663	507	Structure Controlled	Northwest Rift Zone
NWRZ3	1115	340	Basal Mode Water (190)	
NWRZ4	1345	410	Basal Mode Water (292)	
NWRZ5	807	246	Basal Mode Water (87)	

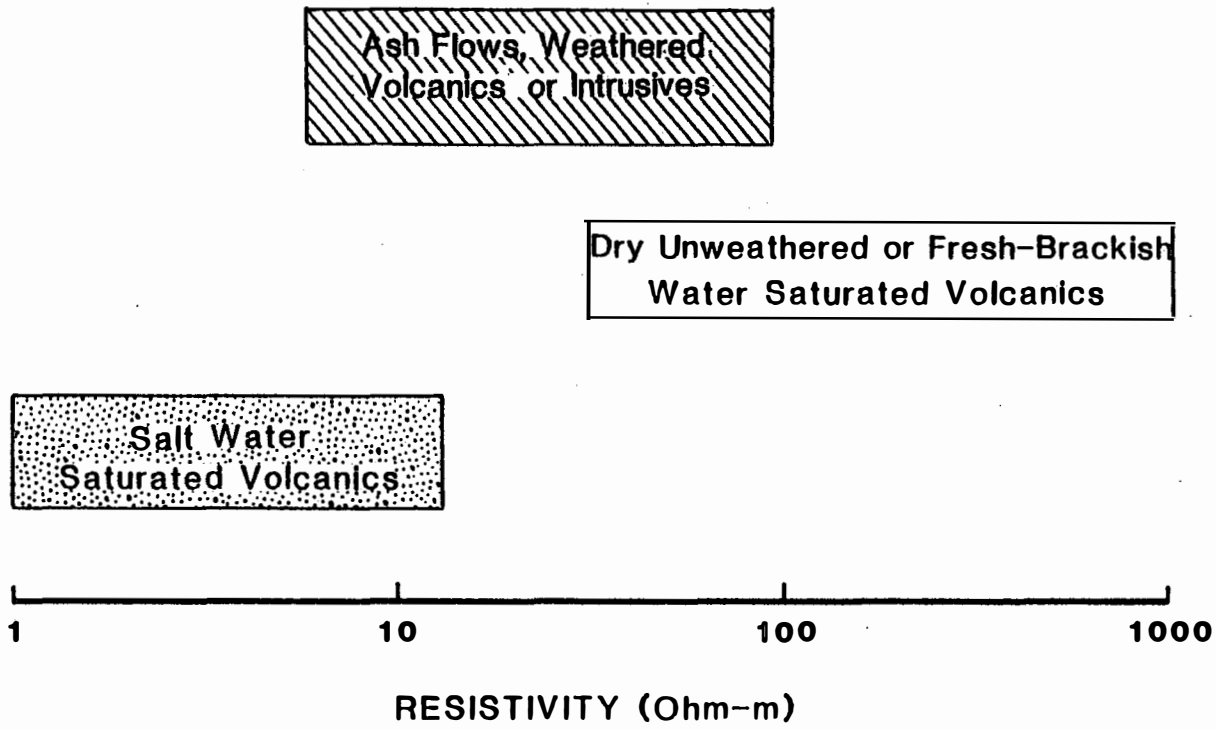
The results are further summarized on the interpretation summary map shown in Figure 5-9. The TDEM soundings are separated into two groups and marked by a color code:

1. Three soundings (blue) beneath which a layer of low resistivity (< 5 ohm-m) was detected below sea level. A fresh-brackish water lens is expected to exist in the basal mode below these three soundings. A thickness for the lens of 292 ft is calculated below Sounding NWRZ4.

2. Two soundings in which high resistivity values are interpreted for the exploration depth interval that extends to about 750 ft below msl (yellow). These soundings are interpreted to be located in the Northwest Rift Zone. Within rift zones, dikes of impermeable rock can provide barriers to ground water flow and high-level water and discontinuities in hydraulic gradients can result.

The ability of determining the exact location of the ground water damming structures in the Northwest Rift Project area is limited because of the distance between data points along the transect. With additional TDEM soundings between the existing data, a better definition of the lateral limits of the hydrogeologic boundary could be made.

Stearns, H.T., 1936. Geology and ground-water resources of Lanai and Kahoolawe, Hawaii. Division of Hydrography, Bulletin 6, pp. 22-60.



CEES BLACKHAWK GEOSCIENCES DIVISION

CHARACTERISTIC RESISTIVITY RANGES

LANAI WATER COMPANY, INC.
ISLAND OF LANAI, HAWAII

PROJECT NO. 9081-000 FIGURE 5-1

B
SOUTHWEST

B'
NORTHEAST

SOUNDING NUMBER

PB 17 | PB 3 | PB 2 | PB 7 | PB 6

PUU ULAULA

MANELE ROAD

WELL 1 (OFFSET 3000' NORTH)

GROUND SURFACE

HEAD = 818'

TD – 3 FT

SEA LEVEL

POSITION AND WIDTH OF DISCONTINUITY UNCERTAIN

ELEVATION (FEET)

1400
1200
800
400
0
-400
-800
-1200
-1400

30 | 37 | 48 | 32 | 153 | 3.4

441 | 684 | 199 | 1009 | 234

2.5 | 4.5 | 25 | 23 | 19

BASAL MODE GROUND WATER

INFERRED GEOLOGIC/HYDROLOGIC GROUND WATER DAMMING STRUCTURE

MAXIMUM DEPTH OF EXPLORATION

POTENTIAL HIGH-LEVEL GROUND WATER

400 FT
2000 FT
0

LEGEND

33 Resistivity in ohm-m

Laterite Soil

Dry Unweathered or Fresh-Brackish Water Saturated Volcanics

Inferred Structure (Possible Ash Flows, Weathered Volcanics or Intrusives)

Salt Water Saturated Volcanics

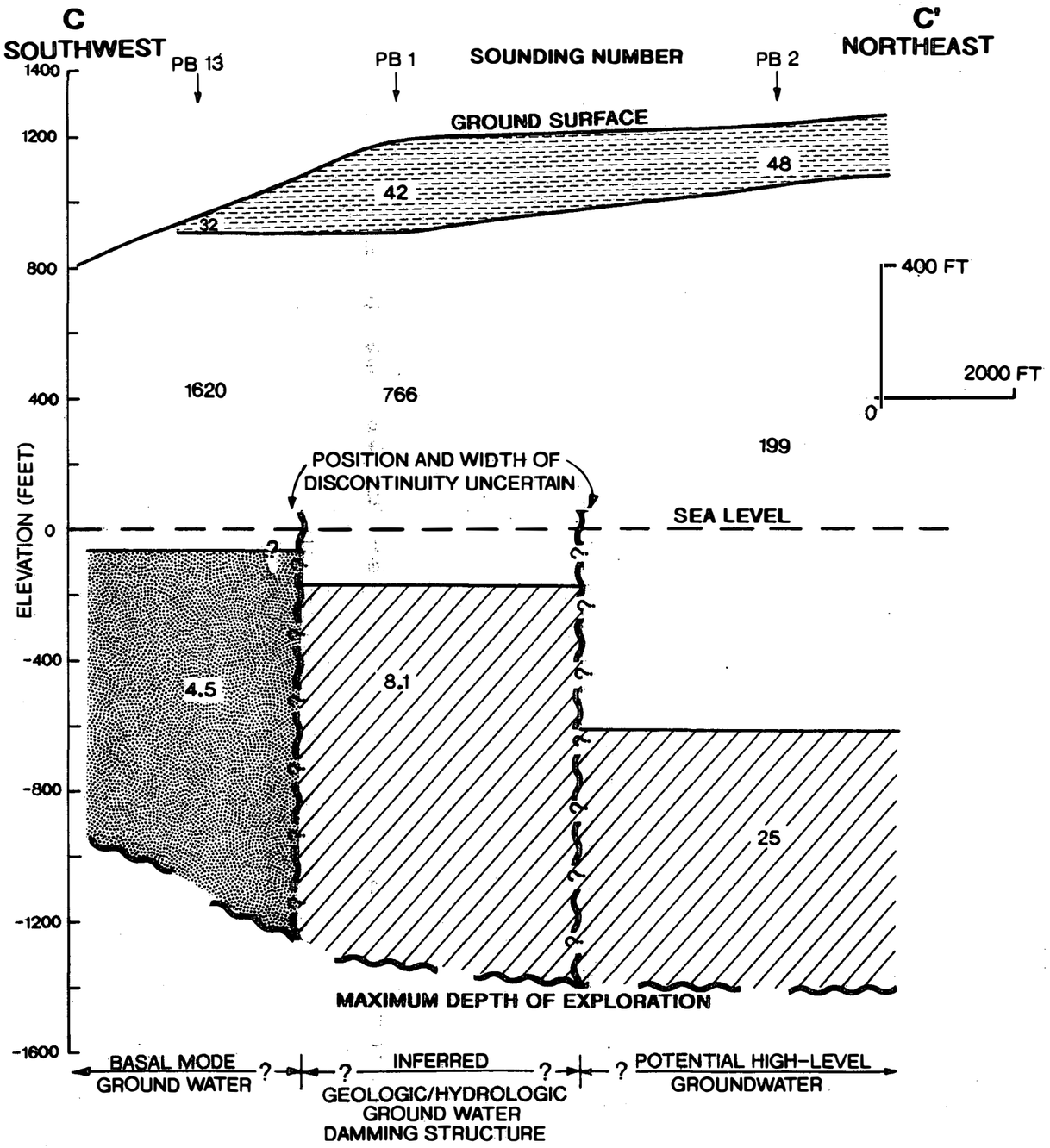
Inferred Geologic/Hydrologic Discontinuity

BLACKHAWK GEOSCIENCES DIVISION

GEOELECTRIC CROSS SECTION PALAWAI BASIN LINE B-B'

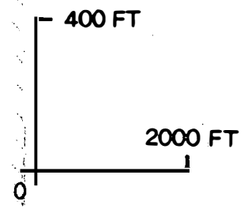
LANAI WATER COMPANY, INC.
ISLAND OF LANAI, HAWAII

PROJECT NO. 9081-000 FIGURE 5-3



LEGEND

- 33 — Resistivity in ohm-m
- Laterite Soil
- Dry Unweathered or Fresh-Brackish Water Saturated Volcanics
- Inferred Structure (Possible Ash Flows, Weathered Volcanics or Intrusives)
- Salt Water Saturated Volcanics
- Inferred Geologic/Hydrologic Discontinuity

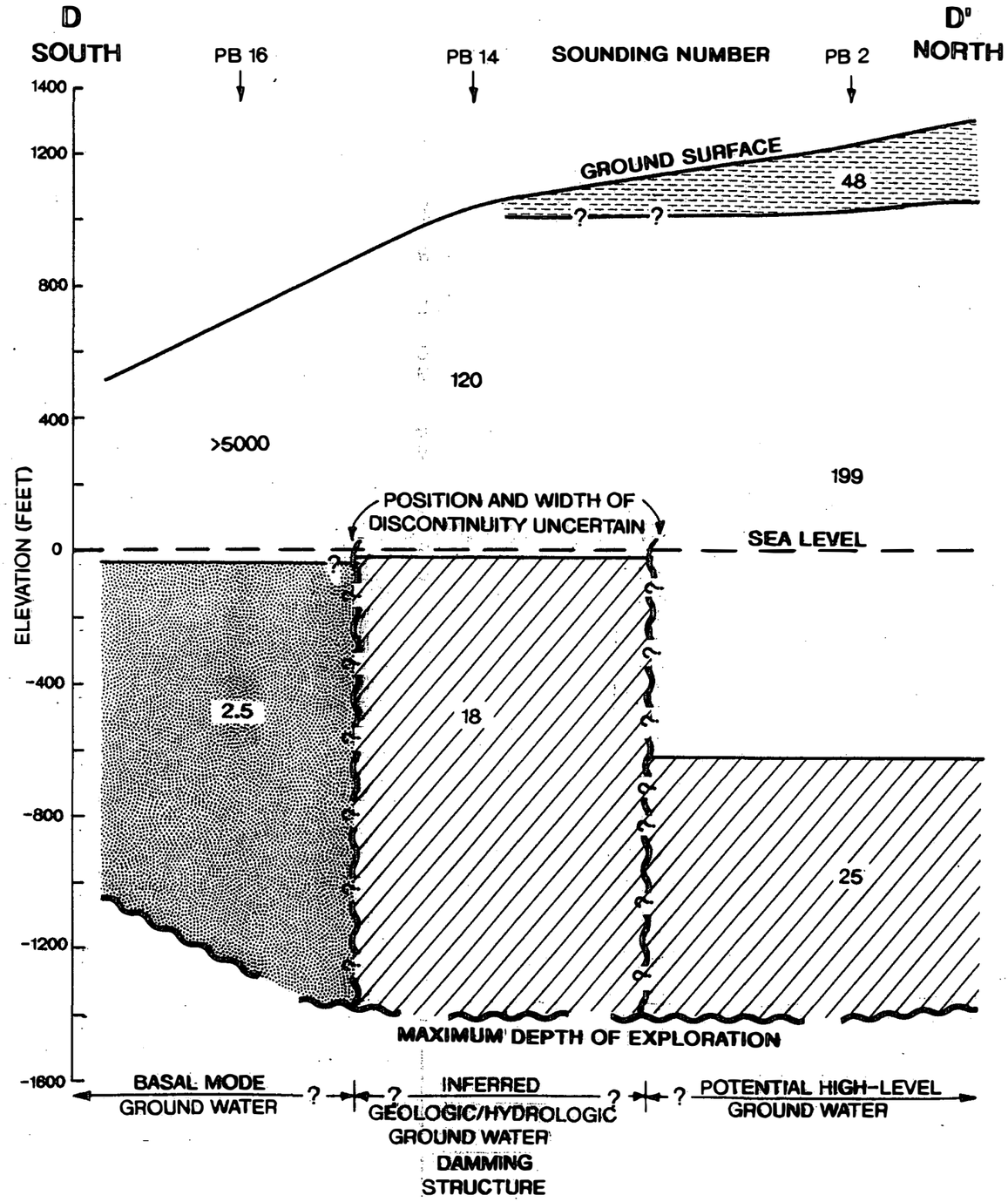


CEES BLACKHAWK GEOSCIENCES DIVISION

GEOELECTRIC CROSS SECTION PALAWAI BASIN LINE C-C'

LANAI WATER COMPANY, INC.
ISLAND OF LANAI, HAWAII

PROJECT NO. 9081-000 FIGURE 5-4



LEGEND

33 Resistivity in ohm-m

Laterite Soil

Dry Unweathered or Fresh-Brackish Water Saturated Volcanics

Inferred Structure (Possible Ash Flows, Weathered Volcanics or Intrusives)

Salt Water Saturated Volcanics

Inferred Geologic/Hydrologic Discontinuity

400 FT

2000 FT

0

CEES BLACKHAWK GEOSCIENCES DIVISION

GEOELECTRIC CROSS SECTION PALAWAI BASIN LINE D-D'

LANAI WATER COMPANY, INC.
ISLAND OF LANAI, HAWAII

PROJECT NO. 9081-000 FIGURE 5-5

E

SOUTH

(LINE 2, 1993 DATA)

1 2 5 3 4

PB 5 PB 7 PB 9 SOUNDING NUMBER PB 8

WELL 10 (OFFSET 800' WEST)

WELL 9 (OFFSET 3500' EAST)

E'

NORTH

GROUND SURFACE

GROUND SURFACE

122

39

37

51

32

25

HEAD = 812'

HEAD = 210'

218

238

1931

1657

250

1141

POSITION AND WIDTH OF DISCONTINUITY UNCERTAIN

SEA LEVEL

SEA LEVEL

TD UNKNOWN

2874

243

143

TD-225'

3.8

2.8

3.4

6.3

5.6

23

47

23

13

ELEVATION (FEET)

1600

1200

800

400

0

-400

-800

-1200

MAXIMUM DEPTH OF EXPLORATION

BASAL MODE GROUND WATER

POTENTIAL HIGH-LEVEL GROUND WATER

INFERRED GEOLOGIC/HYDROLOGIC GROUND WATER DAMMING STRUCTURE

400 FT

2000 FT

0

LEGEND

33 Resistivity in ohm-m

Laterite Soil

Dry Unweathered or Fresh-Brackish Water Saturated Volcanics

Inferred Structure (Possible Ash Flows, Weathered Volcanics or Intrusives)

Salt Water Saturated Volcanics

Inferred Geologic/Hydrologic Discontinuity

BLACKHAWK GEOSCIENCES DIVISION

GEOELECTRIC CROSS SECTION PALAWAI BASIN LINE E-E'

LANAI WATER COMPANY, INC.
ISLAND OF LANAI, HAWAII

PROJECT NO. 9081-000 FIGURE 5-6

F
SOUTH

F'
NORTH

(LINE 1 1993 DATA)

SOUNDING NUMBER

1 2 3 4 5 6 PB 20 PB 6

WELL 1 (OFFSET 3000' NORTH)

ELEVATION (FEET)

1600 1200 800 400 0 -400 -800 -1200 -1600

1400 1200 800 400 0 -400 -800 -1200 -1600

GROUND SURFACE

MANELE WELL

HEAD = 1.1'

HEAD = 818'

POSITION AND WIDTH OF DISCONTINUITY UNCERTAIN

SEA LEVEL

TD -3'

MAXIMUM DEPTH OF EXPLORATION

84 57 172 768 288 216 56 153 34 165 679 519 950 1009 1.8 1.8 2.9 9.0 29 260 ? 11 19

BASAL MODE GROUND WATER

INFERRED GEOLOGIC/HYDROLOGIC GROUND WATER DAMMING STRUCTURE

POTENTIAL HIGH-LEVEL GROUND WATER

LEGEND

33 Resistivity in ohm-m

Laterite Soil

Dry Unweathered or Fresh-Brackish Water Saturated Volcanics

Inferred Structure (Possible Ash Flows, Weathered Volcanics or Intrusives)

Salt Water Saturated Volcanics

Inferred Geologic/Hydrologic Discontinuity

400 FT

2000 FT

0

CEES BLACKHAWK GEOSCIENCES DIVISION

GEOELECTRIC CROSS SECTION PALAWAI BASIN LINE F-F'

LANAI WATER COMPANY, INC.
ISLAND OF LANAI, HAWAII

PROJECT NO. 9081-000 FIGURE 5-7

G
SOUTH

G'
NORTH

PB 18 | PB 19 | PB 20 | PB 6 | SOUNDING NUMBER

PUU MAHANALUA

WELL 1 (OFFSET 3000' NORTH)

GROUND SURFACE

WELL 12

HEAD = 818'

BOUNDARY EXTRAPOLATED FROM 1993 LINE 1 DATA POSITION AND WIDTH OF DISCONTINUITY UNCERTAIN

HEAD = 5'

TD - 15'

TD -3'

SEA LEVEL

MAXIMUM DEPTH OF EXPLORATION

ELEVATION (FEET)

1600
1200
800
400
0
-400
-800
-1200
-1800

1400
1200
800
400
0
-400
-800
-1200
-1600

39
56
153
3.4
25
603
216
677
1009
3.2
11
22
19

BASAL MODE GROUND WATER

INFERRED GEOLOGIC/HYDROLOGIC GROUND WATER DAMMING STRUCTURE

POTENTIAL HIGH-LEVEL GROUND WATER

LEGEND

33 Resistivity in ohm-m

Laterite Soil

Dry Unweathered or Fresh-Brackish Water Saturated Volcanics

Inferred Structure (Possible Ash Flows, Weathered Volcanics or Intrusives)

Salt Water Saturated Volcanics

Inferred Geologic/Hydrologic Discontinuity

400 FT

2000 FT

0

CEES BLACKHAWK GEOSCIENCES DIVISION

GEOELECTRIC CROSS SECTION PALAWAI BASIN LINE G-G'

LANAI WATER COMPANY, INC.
ISLAND OF LANAI, HAWAII

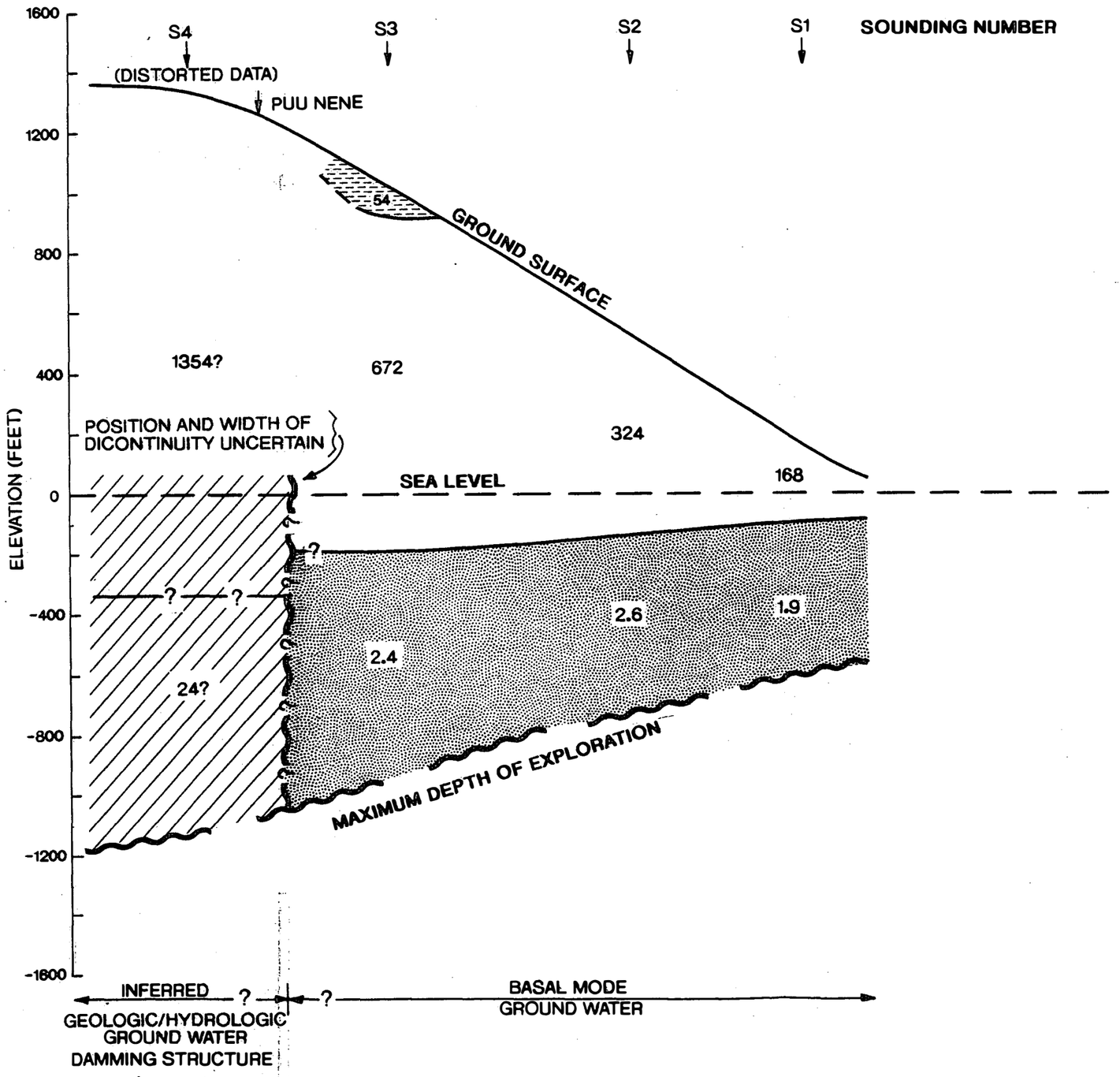
PROJECT NO. 9081-000 FIGURE 5-8

MAP GOES HERE

SOUTHWEST

LINE 1

NORTHEAST



LEGEND

33 Resistivity in ohm-m

Laterite Soil

Dry Unweathered or Fresh-Brackish Water Saturated Volcanics

Inferred Structure (Possible Ash Flows, Weathered Volcanics or Intrusives)

Salt Water Saturated Volcanics

Inferred Geologic/Hydrologic Discontinuity

400 FT

2000 FT

0

CEES BLACKHAWK GEOSCIENCES DIVISION

GEOELECTRIC CROSS SECTION
WINDWARD COAST LINE 1
LANAI WATER COMPANY, INC.
ISLAND OF LANAI, HAWAII

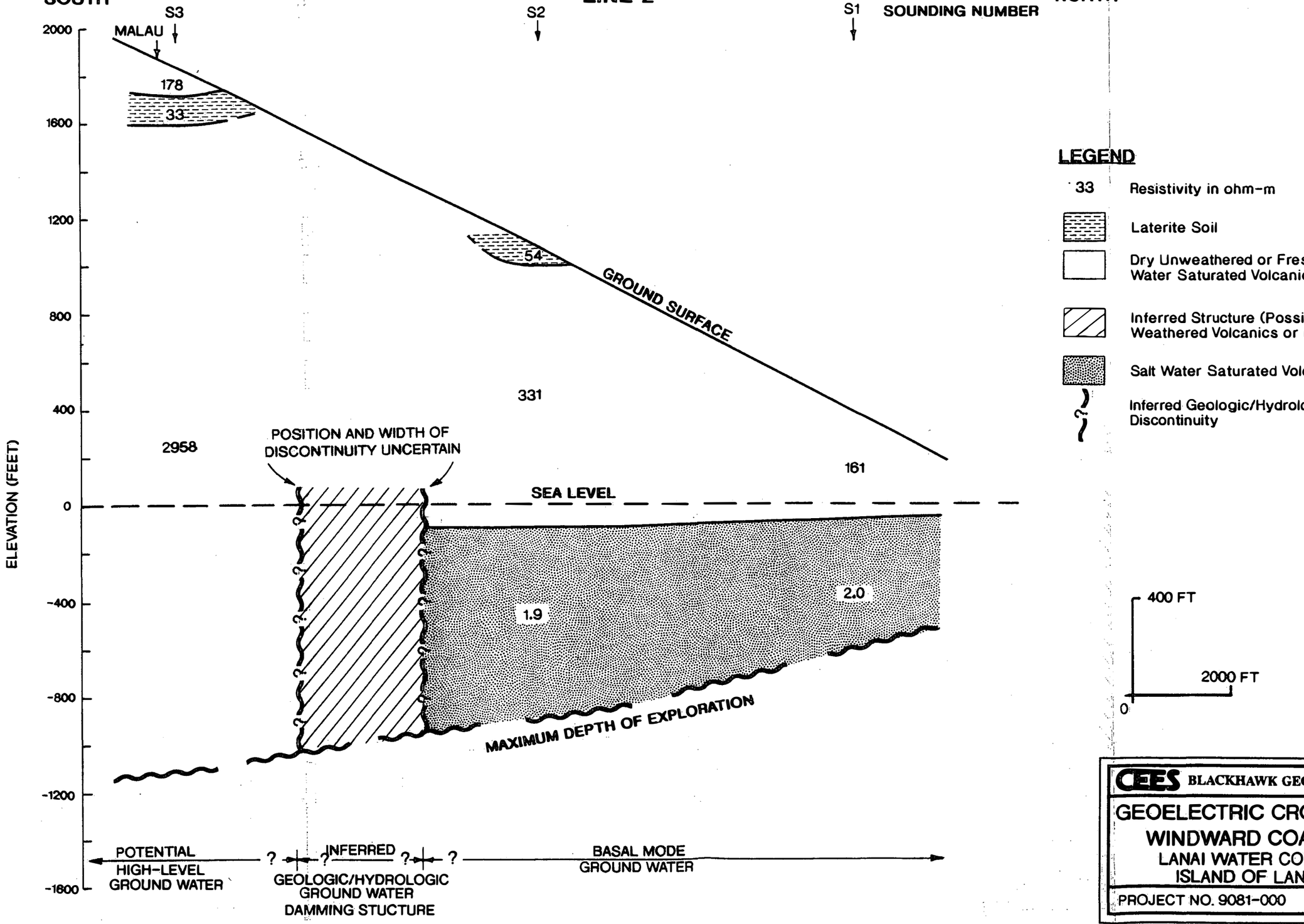
PROJECT NO. 9081-000 FIGURE 5-10

LINE 2

SOUTH

NORTH

SOUNDING NUMBER



LEGEND

- 33 — Resistivity in ohm-m
- Laterite Soil
- Dry Unweathered or Fresh-Brackish Water Saturated Volcanics
- Inferred Structure (Possible Ash Flows, Weathered Volcanics or Intrusives)
- Salt Water Saturated Volcanics
- Inferred Geologic/Hydrologic Discontinuity

400 FT

2000 FT

0

CEES BLACKHAWK GEOSCIENCES DIVISION

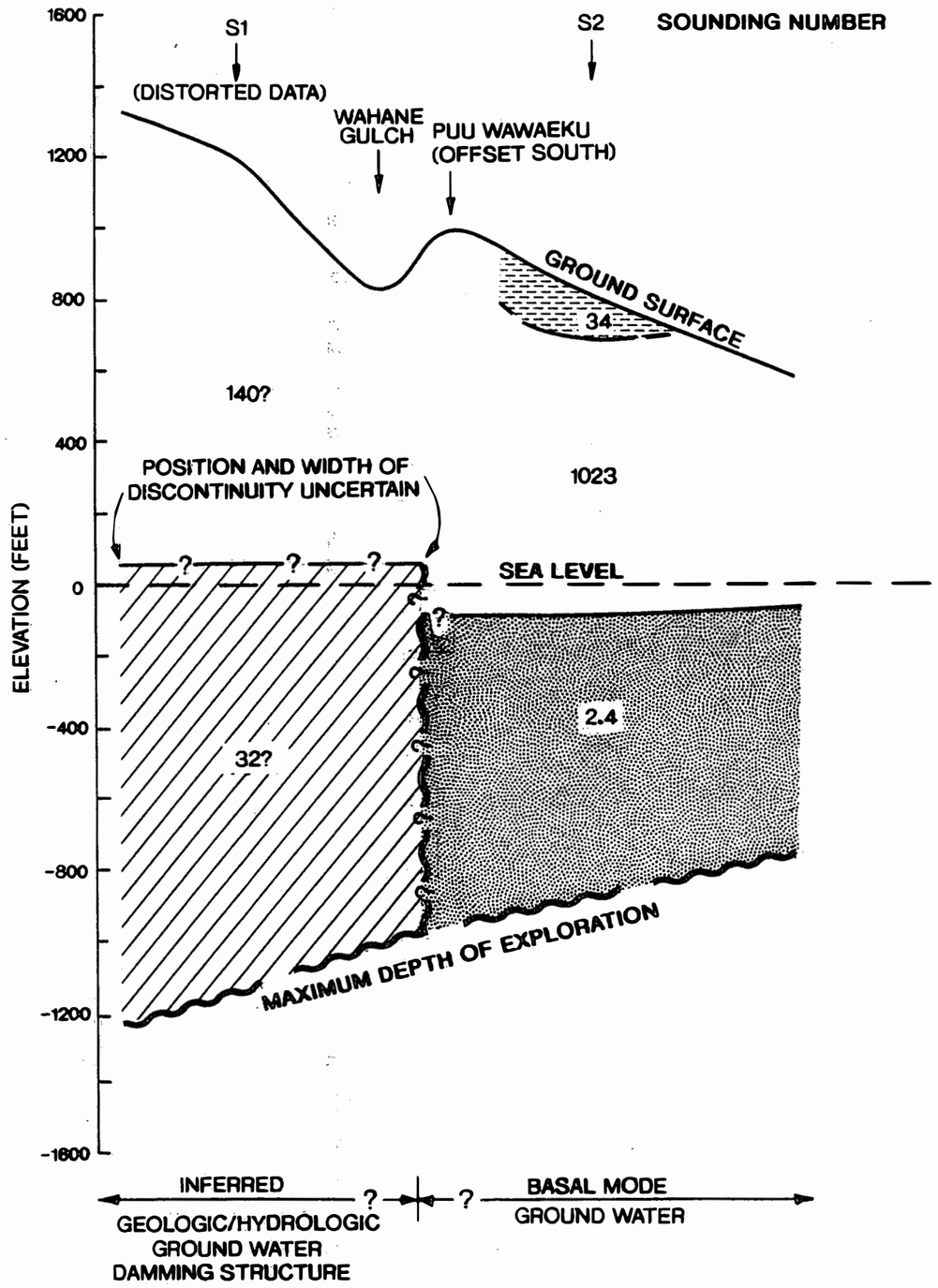
GEOELECTRIC CROSS SECTION
WINDWARD COAST LINE 2
LANAI WATER COMPANY, INC.
ISLAND OF LANAI, HAWAII

PROJECT NO. 9081-000 FIGURE 5-11

SOUTHWEST

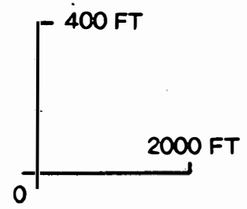
LINE 3

NORTHEAST



LEGEND

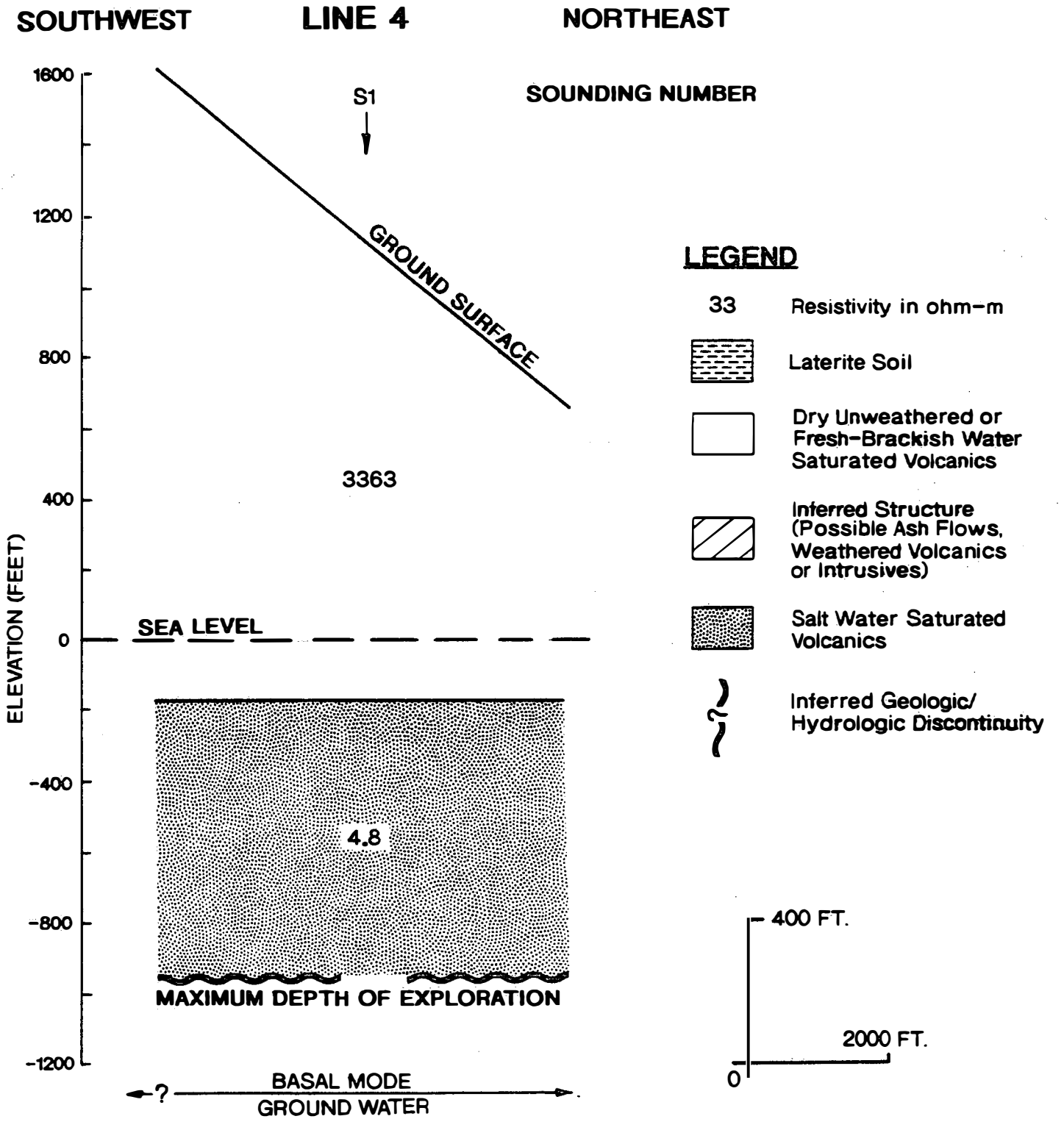
- 33 — Resistivity in ohm-m
- Laterite Soil
- Dry Unweathered or Fresh-Brackish Water Saturated Volcanics
- Inferred Structure (Possible Ash Flows, Weathered Volcanics or Intrusives)
- Salt Water Saturated Volcanics
- Inferred Geologic/Hydrologic Discontinuity



CEES BLACKHAWK GEOSCIENCES DIVISION

GEOELECTRIC CROSS SECTION
WINDWARD COAST LINE 3
LANAI WATER COMPANY, INC.
ISLAND OF LANAI, HAWAII

PROJECT NO. 9081-000 FIGURE 5-12

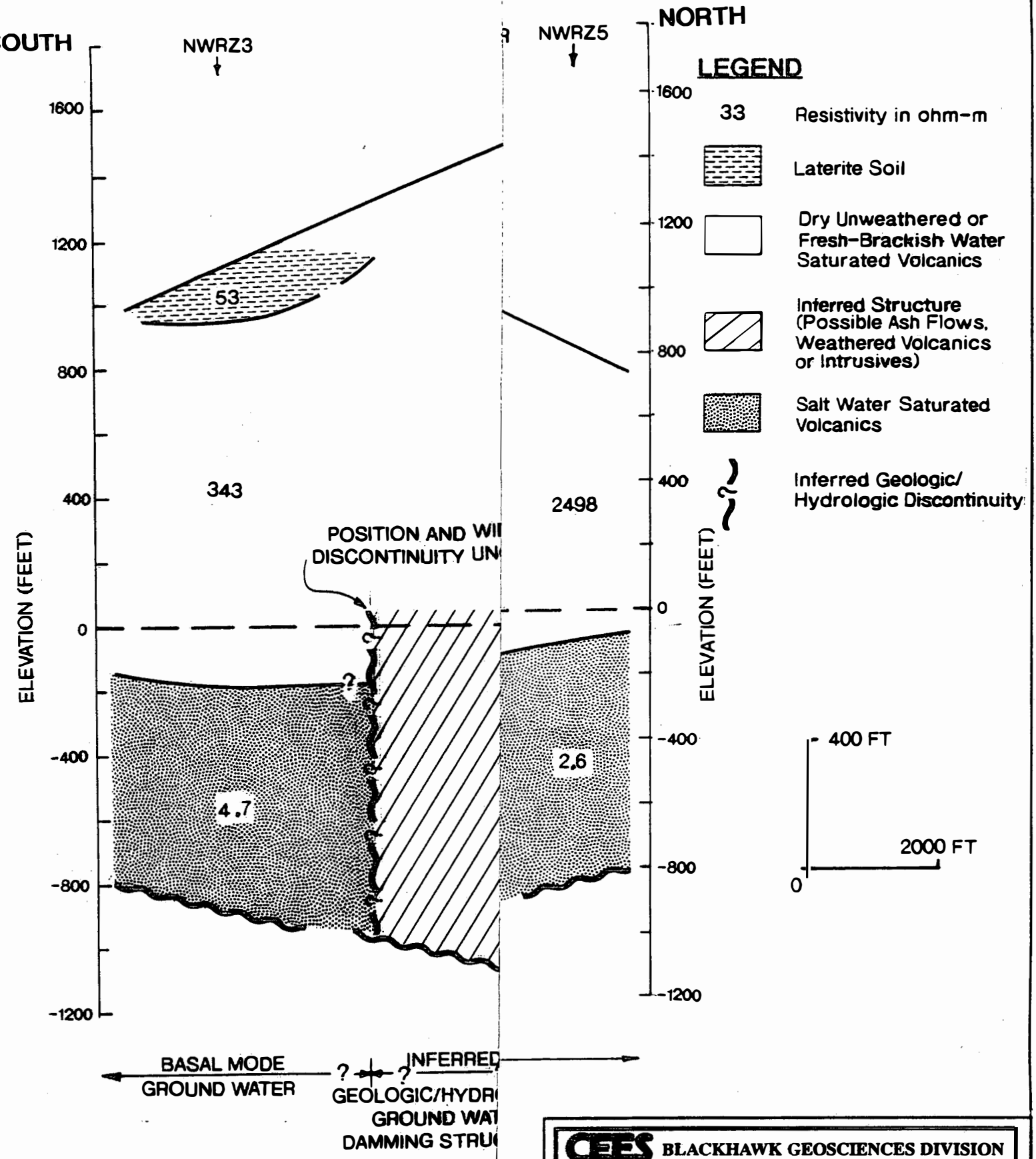


CES BLACKHAWK GEOSCIENCES DIVISION

GEOELECTRIC CROSS SECTION WINDWARD COAST LINE 4

LANAI WATER COMPANY, INC.
ISLAND OF LANAI, HAWAII

PROJECT NO. 9081-000 FIGURE 5-13



CEES BLACKHAWK GEOSCIENCES DIVISION

GEOELECTRIC CROSS SECTION NORTHWEST RIFT LINE 5

LANAI WATER COMPANY, INC.
ISLAND OF LANAI, HAWAII

PROJECT NO. 9081-000 FIGURE 5-14

6.0 CONCLUSIONS AND RECOMMENDATIONS

General

The main objective of the TDEM surveys was to assist in the basal and high-level ground water resource evaluation at each of the three (Palawai Basin, Windward Coast and Northwest Rift) project areas on Lanai, HI. The interpretations derived from the survey are shown in Figure 5-9. Three distinct areas of hydrogeologic behavior are observed in the summary map:

1. Areas where ground water is expected in the basal mode. The salt water interface is detected in these soundings and the thickness of the fresh-brackish water lens can be calculated from the interpreted interface from each sounding. The accuracy in determining the depth to the salt water saturated interface is estimated to be ± 5% of the total depth measured.

2. Areas where resistivity values are expected to be influenced by lateral discontinuities and where ground water flow is controlled by geologic/hydrologic barriers (e.g., faults or dikes). Within this area, ground water levels, water quality and production are expected to be highly variable.

3. Areas of structurally controlled ground water (potential high-level water). The interpreted boundary between the geologic/hydrologic discontinuity and structure controlled ground water occurs at different elevations at each project area.

The relative accuracy in determining the exact location of the boundary between the geologic/hydrologic discontinuity by TDEM measurements is influenced by several factors:

1. Lateral discontinuities effecting the 1-D interpretations of the TDEM sounding data. The apparent geologic structures causing the damming of the ground water flow may be considerably narrower than the wide geologic/hydrologic discontinuity indicated on Figure 5-9. TDEM measurements are effected by lateral changes in the subsurface and the exact location of these features cannot be determined.

2. Horizontal distances between TDEM measurements (data density) across the discontinuity are in some cases relatively large (greater than 6,000 ft). To help delineate the (inland) hydrogeologic boundary more accurately, additional TDEM soundings are recommended throughout these areas.

Palawai Basin Project

The interpretation of the TDEM surveys at the Palawai Project Area (ref. Figs. 5-2 through 5-9) show that this area is expected to have a complicated ground water regime. The approximate elevation at which basal mode water is expected to occur is below the 490 ft (150 m) elevation level near the Manele Bay Hotel (Sounding PB15) and below the 1,150 ft (350 m) elevation level on the west side of the Palawai Basin Area near Sounding PB17. Much of the area surveyed is interpreted to be influenced by structures (dikes, rift zones, etc.) resulting from the collapsed Palawai caldera and ground water yield, and quality in these areas is expected to be highly variable. In the area surveyed, potential high-level water occurrences are interpreted to exist above the approximate 820 ft (250 m) elevation level in the southern portion of the project area (Line 2, Sounding 4) and at higher elevations of about 1,150 ft (350 m) near

Sounding PB5 which is interpreted to be within the caldera rim. Well head information from Well 10 (210 ft) and Well 9 (812 ft) exhibit the variation of high-level water across the Palawai Basin area. Between these two wells, the potential for high-level water exists with the thickest high resistivity section being interpreted beneath Soundings PB7 and PB9. To better determine the lateral extent of the area of potential high-level ground water, more TDEM soundings would be recommended in areas where data density is limited.

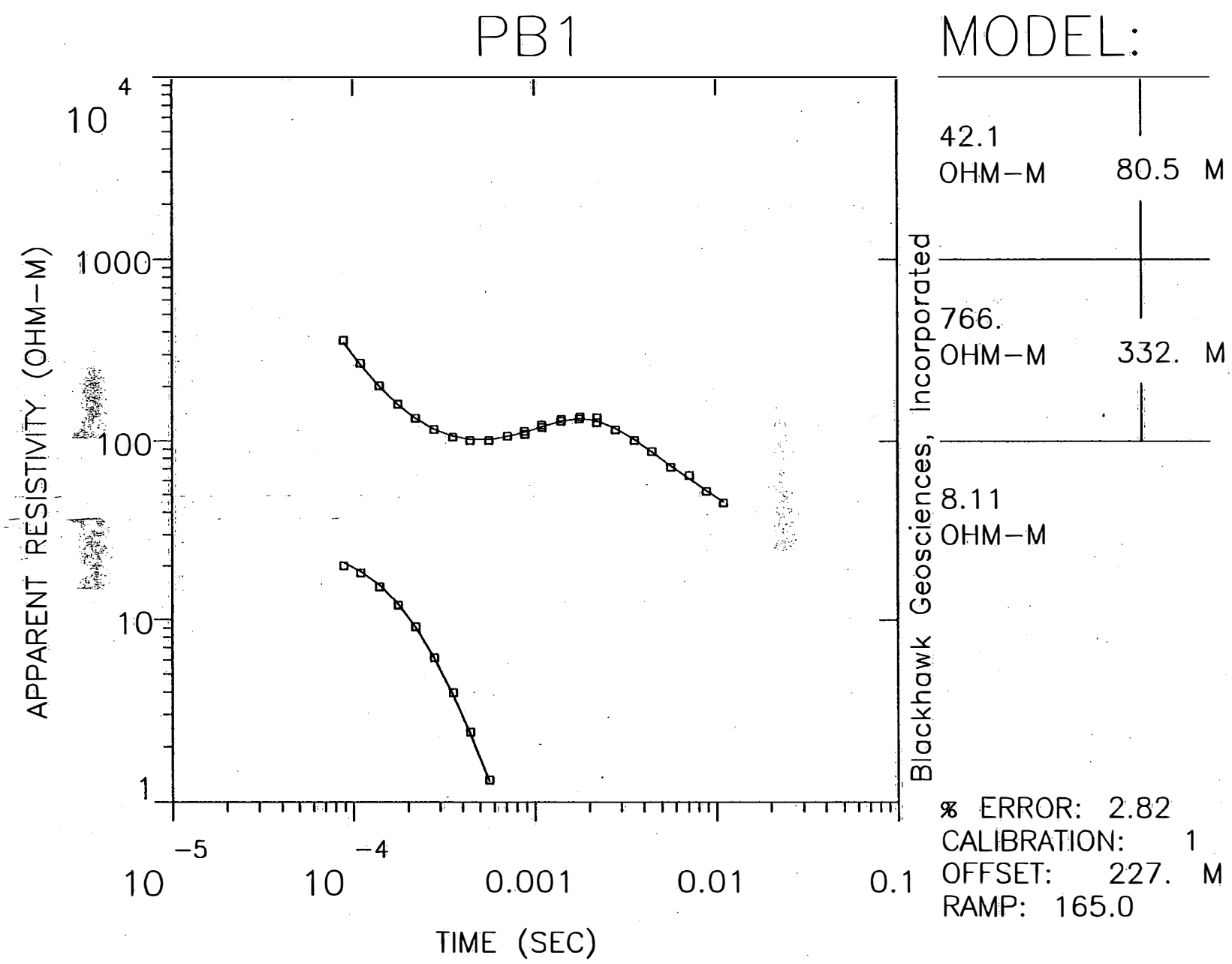
Windward Coast Project

Ten TDEM soundings were acquired in the Windward Coast Project Area and the interpretation results are shown in the northeast portion of the island in Figure 5-9 and in Figures 5-10 through 5-13. In the surveyed area, basal mode water resources are interpreted beneath seven of the ten soundings, and potential high-level water is expected to exist near Sounding L2S3 (Keomuku Road). The objective of the survey for the Windward Coast Project was to determine at what elevation the potential for high-level ground water exists above Halepalaoa Landing and on other lines in the area. But due to limited access in these areas (in some cases distances between lines is greater than two miles), the objective was accomplished only on Line 2. To determine the extent of the area of potential high-level ground water on the other lines, more TDEM soundings would be recommended at higher elevations on Lines 1, 3 and 4. This may be accomplished by either extending the roads into these areas or by helicopter support in this portion of the island.

Northwest Rift Project

From interpretations of the five TDEM soundings at the Northwest Rift Project, a significant change in the geoelectric cross section is inferred on the north side of Sounding NWRZ1 and on the south side of NWRZ2 (ref. Figs. 5-9 and 5-14). Across the survey line, beneath Soundings NWRZ3, NWRZ4 and NWRZ5 basal mode water resources are interpreted, and in the vicinity of Soundings NWRZ1 and NWRZ2 the potential for high-level ground water exists. More TDEM soundings are recommended along Line 5 to help determine the extent of the area of high-level water and transects on either side of the line would also help to define the lateral position of the Northwest Rift Zone.

The results from the geophysical surveys illustrate the usefulness of TDEM surveys in mapping the hydrogeologic boundary between the basal mode water and potential high-level ground water. This information will help in future exploratory well placement and assist in determining regional water resources on the Island of Lanai.



MODEL:

42.1 OHM-M — 80.5 M

766. OHM-M — 332. M

8.11 OHM-M

% ERROR: 2.82
CALIBRATION: 1
OFFSET: 227. M
RAMP: 165.0

PB1

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		358.1	1175.0		
42.15	80.5	277.6	910.8	1.9	1.9
765.84	331.5	-53.9	-176.9	0.4	2.3
8.11					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	3.59E+02	3.50E+02	2.698	
2	1.10E-04	2.68E+02	2.64E+02	1.569	
3	1.40E-04	2.01E+02	1.99E+02	1.075	
4	1.77E-04	1.59E+02	1.58E+02	0.564	
5	2.20E-04	1.34E+02	1.34E+02	-0.097	
6	2.80E-04	1.16E+02	1.16E+02	-0.295	
7	3.55E-04	1.05E+02	1.07E+02	-1.679	
8	4.43E-04	1.01E+02	1.02E+02	-1.476	
9	5.64E-04	1.01E+02	1.02E+02	-1.237	
10	7.13E-04	1.07E+02	1.06E+02	0.849	
11	8.81E-04	1.13E+02	1.12E+02	1.238	
12	8.90E-04	1.09E+02	1.12E+02	-2.789	
13	1.10E-03	1.22E+02	1.20E+02	2.061	
14	1.10E-03	1.19E+02	1.20E+02	-0.882	
15	1.40E-03	1.29E+02	1.29E+02	0.141	
16	1.41E-03	1.32E+02	1.29E+02	2.230	
17	1.77E-03	1.33E+02	1.33E+02	-0.266	
18	1.80E-03	1.36E+02	1.33E+02	1.910	
19	2.20E-03	1.27E+02	1.30E+02	-2.289	
20	2.22E-03	1.34E+02	1.29E+02	3.602	
21	2.80E-03	1.15E+02	1.18E+02	-2.114	
22	3.55E-03	1.01E+02	1.02E+02	-1.485	
23	4.43E-03	8.74E+01	8.73E+01	0.062	
24	5.64E-03	7.14E+01	7.30E+01	-2.261	
25	7.13E-03	6.43E+01	6.15E+01	4.690	
26	8.81E-03	5.25E+01	5.29E+01	-0.737	
27	1.10E-02	4.53E+01	4.56E+01	-0.488	

R: 227. X: 0. Y: 228. DL: 455. REQ: 253. CF: 1.0000
CLHZ ARRAY, 27 DATA POINTS, RAMP: 165.0 MICROSEC, DATA: PB1
0508 PB 100WZ OPR XTL H 2 10+100
Ch.21 = 0.16 Ch.22 = 0.089 Ch.23 = 10.5 Ch.24 =
RMS LOG ERROR: 1.21E-02, ANTILOG YIELDS 2.8249 %
LATE TIME PARAMETERS

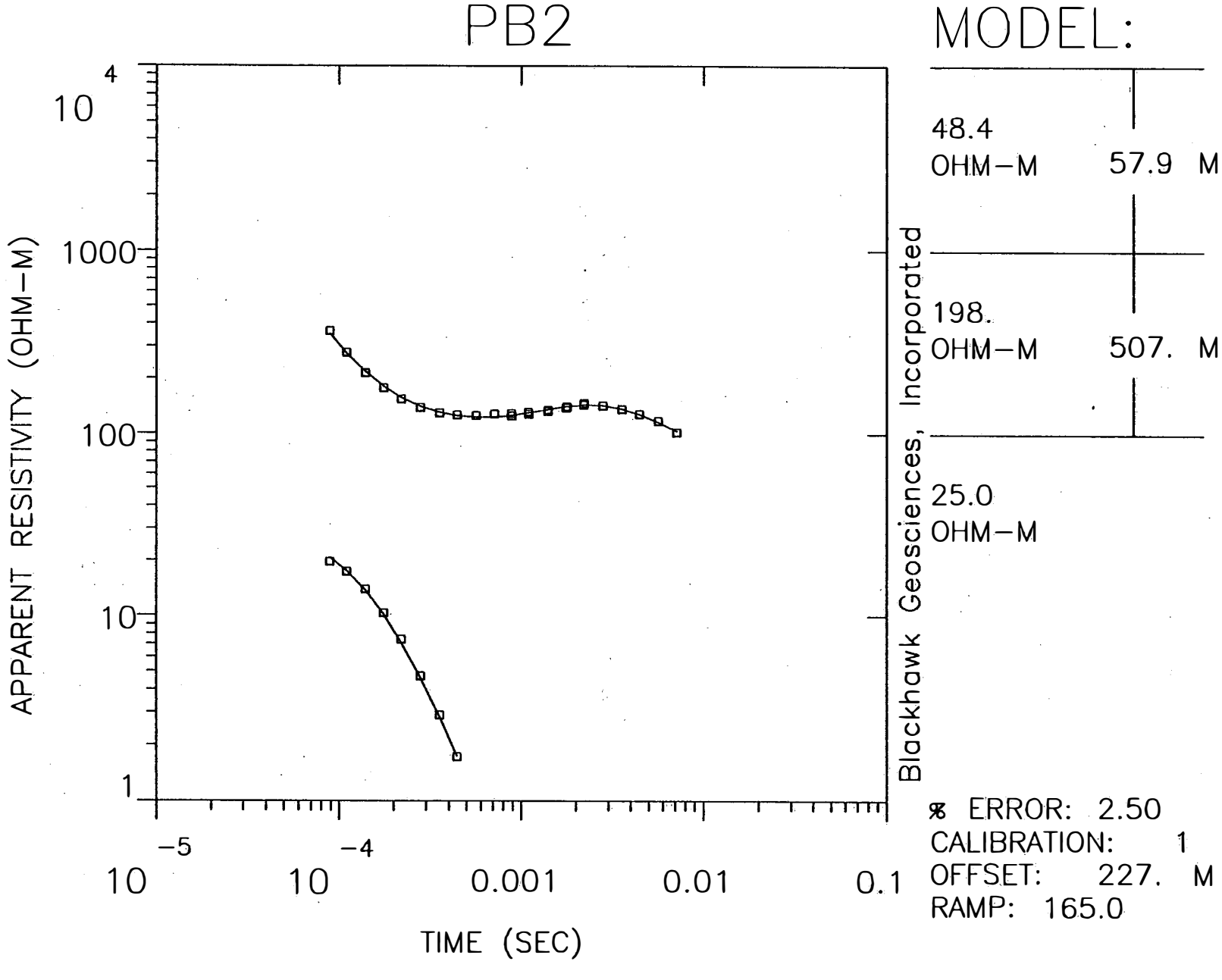
* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER
P 1 0.98
P 2 -0.01 0.03
P 3 0.02 -0.04 0.80
T 1 -0.03 -0.08 0.04 0.95

```
T 2  0.00  0.04  0.01  0.01  1.00
       P 1   P 2   P 3   T 1   T 2
```

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	38.652	42.149	45.805
	2	464.285	765.841	1600.172
	3	6.521	8.114	9.826
THICK	1	70.382	80.525	92.219
	2	318.602	331.527	343.899
DEPTH	1	70.382	80.525	92.219
	2	403.790	412.051	420.353


PB2
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
48.4
OHM-M
57.9 M
198.
OHM-M
507. M
25.0
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 2.50
CALIBRATION: 1
OFFSET: 227. M
RAMP: 165.0

PB2

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		374.0	1227.0		
48.44	57.9	316.1	1037.1	1.2	1.2
197.94	506.9	-190.8	-625.9	2.6	3.8
25.03					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	3.63E+02	3.51E+02	3.647	
2	1.10E-04	2.77E+02	2.75E+02	0.714	
3	1.40E-04	2.15E+02	2.17E+02	-1.060	
4	1.77E-04	1.77E+02	1.80E+02	-1.995	
5	2.20E-04	1.53E+02	1.57E+02	-2.492	
6	2.80E-04	1.39E+02	1.41E+02	-1.464	
7	3.55E-04	1.29E+02	1.31E+02	-1.001	
8	4.43E-04	1.26E+02	1.25E+02	0.747	
9	5.64E-04	1.25E+02	1.23E+02	1.987	
10	7.13E-04	1.28E+02	1.23E+02	3.593	
11	8.81E-04	1.28E+02	1.25E+02	2.394	
12	8.90E-04	1.25E+02	1.26E+02	-0.369	
13	1.10E-03	1.31E+02	1.29E+02	1.037	
14	1.10E-03	1.28E+02	1.30E+02	-1.143	
15	1.40E-03	1.33E+02	1.35E+02	-1.704	
16	1.41E-03	1.34E+02	1.35E+02	-0.729	
17	1.77E-03	1.39E+02	1.40E+02	-1.081	
18	1.80E-03	1.40E+02	1.41E+02	-0.489	
19	2.20E-03	1.44E+02	1.43E+02	0.217	
20	2.22E-03	1.46E+02	1.43E+02	2.139	
21	2.80E-03	1.42E+02	1.42E+02	0.050	
22	3.55E-03	1.36E+02	1.36E+02	-0.416	
23	4.43E-03	1.28E+02	1.27E+02	0.507	
24	5.64E-03	1.17E+02	1.15E+02	1.628	
25	7.13E-03	1.02E+02	1.04E+02	-1.462	

R: 227. X: 0. Y: 228. DL: 455. REQ: 253. CF: 1.0000
CLHZ ARRAY, 25 DATA POINTS, RAMP: 165.0 MICROSEC, DATA: PB2
0608 PB 200WZ OPR XTL H 3 8 +100
Ch.21 = 0.16 Ch.22 = 0.089 Ch.23 = 10.5 Ch.24 =
RMS LOG ERROR: 1.07E-02, ANTILOG YIELDS 2.4999 %
LATE TIME PARAMETERS

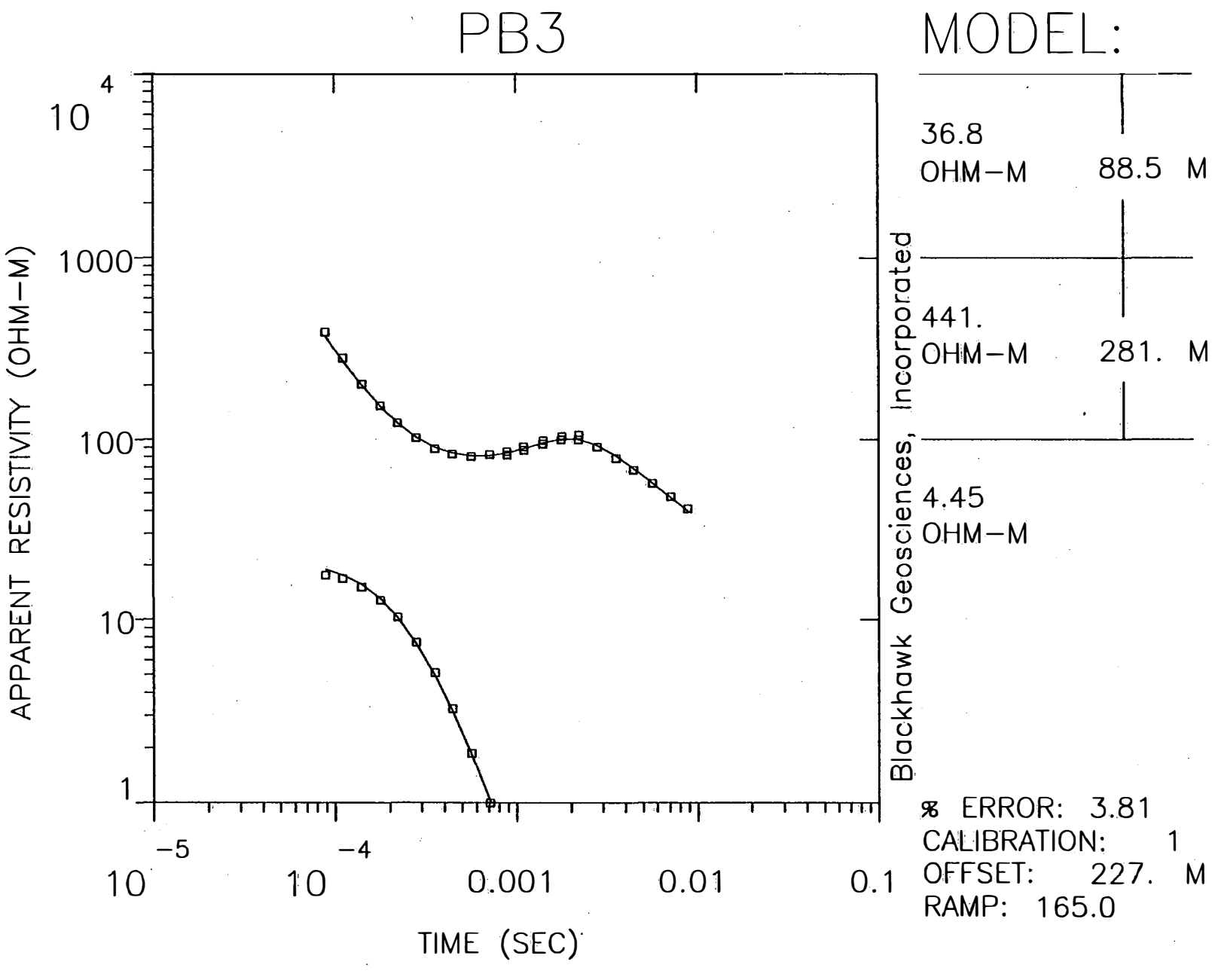
* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER
P 1 1.00
P 2 0.00 1.00
P 3 0.00 -0.01 0.98

```
T 1   0.00   0.00 -0.01   0.99
T 2   0.00   0.00   0.00   0.00   1.00
        P 1    P 2    P 3    T 1    T 2
```

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	44.667	48.440	54.615
	2	179.685	197.939	231.887
	3	17.365	25.025	36.803
THICK	1	48.343	57.891	75.585
	2	462.713	506.877	536.928
DEPTH	1	48.343	57.891	75.585
	2	532.962	564.768	589.822


PB3
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
36.8
OHM-M
88.5 M
441.
OHM-M
281. M
4.45
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 3.81
CALIBRATION: 1
OFFSET: 227. M
RAMP: 165.0

PB3

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		391.1	1283.0		
36.83	88.5	302.5	992.6	2.4	2.4
441.36	281.3	21.3	69.8	0.6	3.0
4.45					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	3.91E+02	3.71E+02	5.488	
2	1.10E-04	2.83E+02	2.73E+02	3.414	
3	1.40E-04	2.03E+02	1.99E+02	1.994	
4	1.77E-04	1.54E+02	1.52E+02	0.774	
5	2.20E-04	1.23E+02	1.24E+02	-0.304	
6	2.80E-04	1.02E+02	1.03E+02	-1.039	
7	3.55E-04	8.87E+01	9.06E+01	-2.139	
8	4.43E-04	8.27E+01	8.39E+01	-1.468	
9	5.64E-04	8.02E+01	8.08E+01	-0.668	
10	7.13E-04	8.23E+01	8.11E+01	1.487	
11	8.81E-04	8.54E+01	8.39E+01	1.747	
12	8.90E-04	8.18E+01	8.41E+01	-2.780	
13	1.10E-03	9.09E+01	8.88E+01	2.322	
14	1.10E-03	8.66E+01	8.89E+01	-2.613	
15	1.40E-03	9.40E+01	9.55E+01	-1.529	
16	1.41E-03	9.80E+01	9.57E+01	2.418	
17	1.77E-03	9.97E+01	1.00E+02	-0.462	
18	1.80E-03	1.04E+02	1.00E+02	3.430	
19	2.20E-03	9.96E+01	9.99E+01	-0.337	
20	2.22E-03	1.06E+02	9.98E+01	5.960	
21	2.80E-03	9.08E+01	9.29E+01	-2.184	
22	3.55E-03	7.83E+01	8.11E+01	-3.457	
23	4.43E-03	6.77E+01	6.91E+01	-2.000	
24	5.64E-03	5.68E+01	5.70E+01	-0.390	
25	7.13E-03	4.78E+01	4.72E+01	1.244	
26	8.81E-03	4.10E+01	4.00E+01	2.617	

R: 227. X: 0. Y: 228. DL: 455. REQ: 253. CF: 1.0000
CLHZ ARRAY, 26 DATA POINTS, RAMP: 165.0 MICROSEC, DATA: PB3
0608 PB 300WZ OPR XTL H 3 8 +100
Ch.21 = 0.165 Ch.22 = 0.089 Ch.23 = 11 Ch.24 =
RMS LOG ERROR: 1.62E-02, ANTILOG YIELDS 3.8056 %
LATE TIME PARAMETERS

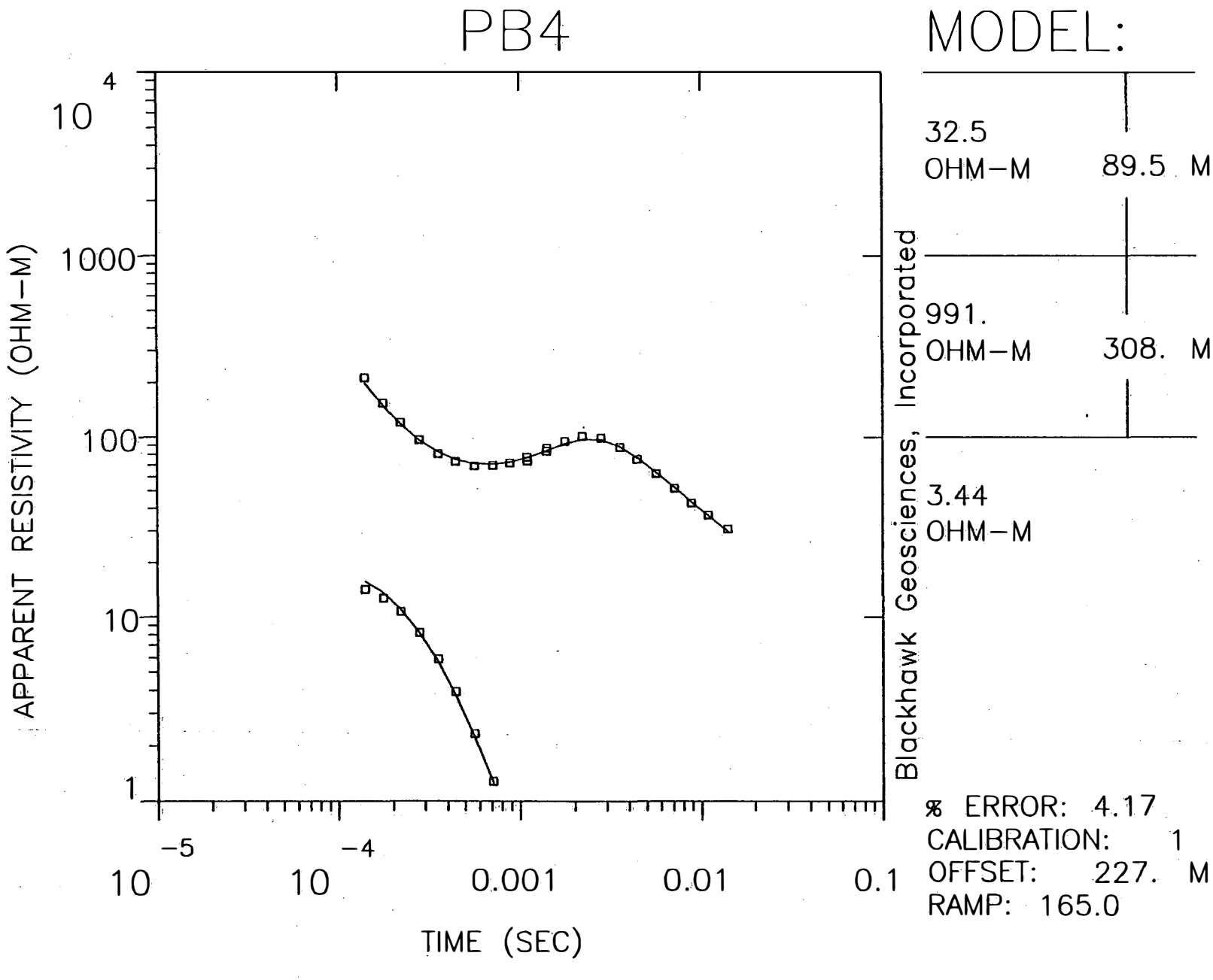
* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER
P 1 0.99
P 2 -0.01 0.04

P 3	0.02	-0.07	0.67		
T 1	-0.02	-0.10	0.04	0.95	
T 2	0.01	0.05	-0.01	0.01	0.99
	P 1	P 2	P 3	T 1	T 2

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	33.029	36.834	40.568
	2	248.196	441.361	923.653
	3	3.032	4.447	6.522
THICK	1	74.290	88.527	105.594
	2	262.524	281.262	298.730
DEPTH	1	74.290	88.527	105.594
	2	364.796	369.789	376.766


PB4
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
32.5
OHM-M
89.5 M
991.
OHM-M
308. M
3.44
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 4.17
CALIBRATION: 1
OFFSET: 227. M
RAMP: 165.0

PB4

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	(FEET)	CONDUCTANCE (S) LAYER	TOTAL
		363.9	1194.0		
32.55	89.5	274.4	900.4	2.7	2.7
990.69	307.6	-33.1	-108.7	0.3	3.1
3.44					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	1.40E-04	2.12E+02	1.99E+02	6.855	
2	1.77E-04	1.55E+02	1.49E+02	4.315	
3	2.20E-04	1.21E+02	1.18E+02	2.021	
4	2.80E-04	9.62E+01	9.62E+01	-0.023	
5	3.55E-04	8.07E+01	8.27E+01	-2.379	
6	4.43E-04	7.32E+01	7.52E+01	-2.729	
7	5.64E-04	6.92E+01	7.12E+01	-2.771	
8	7.13E-04	6.97E+01	7.06E+01	-1.221	
9	8.81E-04	7.19E+01	7.25E+01	-0.869	
10	1.10E-03	7.73E+01	7.69E+01	0.506	
11	1.10E-03	7.36E+01	7.70E+01	-4.345	
12	1.40E-03	8.36E+01	8.40E+01	-0.542	
13	1.41E-03	8.67E+01	8.43E+01	2.819	
14	1.77E-03	9.48E+01	9.18E+01	3.288	
15	2.20E-03	1.01E+02	9.71E+01	4.240	
16	2.80E-03	9.87E+01	9.67E+01	2.160	
17	3.55E-03	8.79E+01	8.86E+01	-0.747	
18	4.43E-03	7.56E+01	7.69E+01	-1.653	
19	5.64E-03	6.26E+01	6.36E+01	-1.527	
20	7.13E-03	5.18E+01	5.22E+01	-0.782	
21	8.81E-03	4.29E+01	4.36E+01	-1.681	
22	1.10E-02	3.67E+01	3.64E+01	0.883	
23	1.41E-02	3.07E+01	2.97E+01	3.329	

R: 227. X: 0. Y: 228. DL: 455. REQ: 253. CF: 1.0000
CLHZ ARRAY, 23 DATA POINTS, RAMP: 165.0 MICROSEC, DATA: PB4
0807 PB 400WZ OPR XTL H 3 8 +100
Ch.21 = 0.165 Ch.22 = 0.089 Ch.23 = 11 Ch.24 =
RMS LOG ERROR: 1.77E-02, ANTILOG YIELDS 4.1676 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

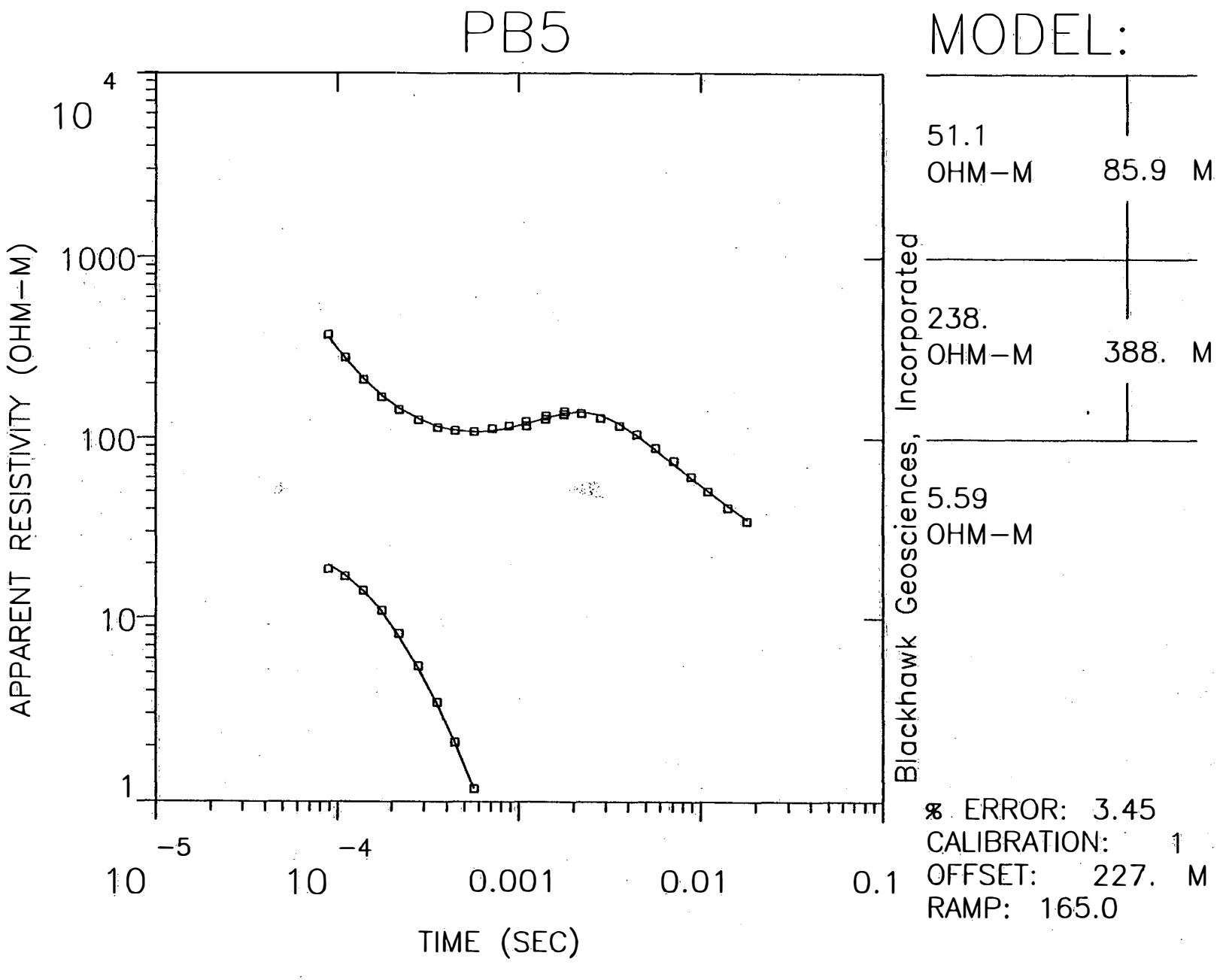
PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.98				
P 2	0.00	0.01			
P 3	0.02	-0.02	0.73		
T 1	-0.02	-0.04	0.04	0.96	
T 2	0.00	0.02	0.00	0.01	1.00

P 1 P 2 P 3 T 1 T 2

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	28.923	32.549	36.085
	2	403.467	990.690	3132.836
	3	2.333	3.438	4.680
THICK	1	75.114	89.483	104.255
	2	291.324	307.581	320.962
DEPTH	1	75.114	89.483	104.255
	2	392.295	397.064	402.359


PB5
MODEL:
APPARENT RESISTIVITY (OHM-M)
10 4
1000
100
10
1
10 -5
10 -4
0.001
0.01
0.1
TIME (SEC)
51.1
OHM-M
85.9 M
238.
OHM-M
388. M
5.59
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 3.45
CALIBRATION: 1
OFFSET: 227. M
RAMP: 165.0

PB5

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		363.9	1194.0		
51.15	85.9	278.0	912.1	1.7	1.7
237.95	388.2	-110.2	-361.5	1.6	3.3
5.59					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	3.74E+02	3.61E+02	3.533	
2	1.10E-04	2.80E+02	2.78E+02	0.881	
3	1.40E-04	2.12E+02	2.13E+02	-0.627	
4	1.77E-04	1.70E+02	1.72E+02	-1.495	
5	2.20E-04	1.43E+02	1.47E+02	-2.204	
6	2.80E-04	1.26E+02	1.28E+02	-1.532	
7	3.55E-04	1.15E+02	1.17E+02	-1.583	
8	4.43E-04	1.10E+02	1.11E+02	-0.227	
9	5.64E-04	1.09E+02	1.08E+02	0.765	
10	7.13E-04	1.13E+02	1.10E+02	2.712	
11	8.81E-04	1.17E+02	1.14E+02	2.745	
12	1.10E-03	1.24E+02	1.21E+02	2.871	
13	1.10E-03	1.18E+02	1.21E+02	-2.620	
14	1.40E-03	1.28E+02	1.30E+02	-1.494	
15	1.41E-03	1.33E+02	1.30E+02	2.489	
16	1.77E-03	1.36E+02	1.38E+02	-1.242	
17	1.80E-03	1.41E+02	1.38E+02	2.505	
18	2.20E-03	1.37E+02	1.40E+02	-2.171	
19	2.80E-03	1.29E+02	1.34E+02	-3.905	
20	3.55E-03	1.17E+02	1.20E+02	-2.629	
21	4.43E-03	1.05E+02	1.04E+02	0.872	
22	5.64E-03	8.87E+01	8.63E+01	2.700	
23	7.13E-03	7.48E+01	7.15E+01	4.614	
24	8.81E-03	6.10E+01	6.03E+01	1.267	
25	1.10E-02	5.07E+01	5.07E+01	-0.124	
26	1.41E-02	4.11E+01	4.19E+01	-2.051	
27	1.80E-02	3.45E+01	3.53E+01	-2.184	

R: 227. X: 0. Y: 228. DL: 455. REQ: 253. CF: 1.0000
CLHZ ARRAY, 27 DATA POINTS, RAMP: 165.0 MICROSEC, DATA: PB5
0807 PB 500WZ OPR XTL H 3 8 +100
Ch.21 = 0.165 Ch.22 = 0.089 Ch.23 = 11 Ch.24 =
RMS LOG ERROR: 1.47E-02, ANTILOG YIELDS 3.4534 %
LATE TIME PARAMETERS

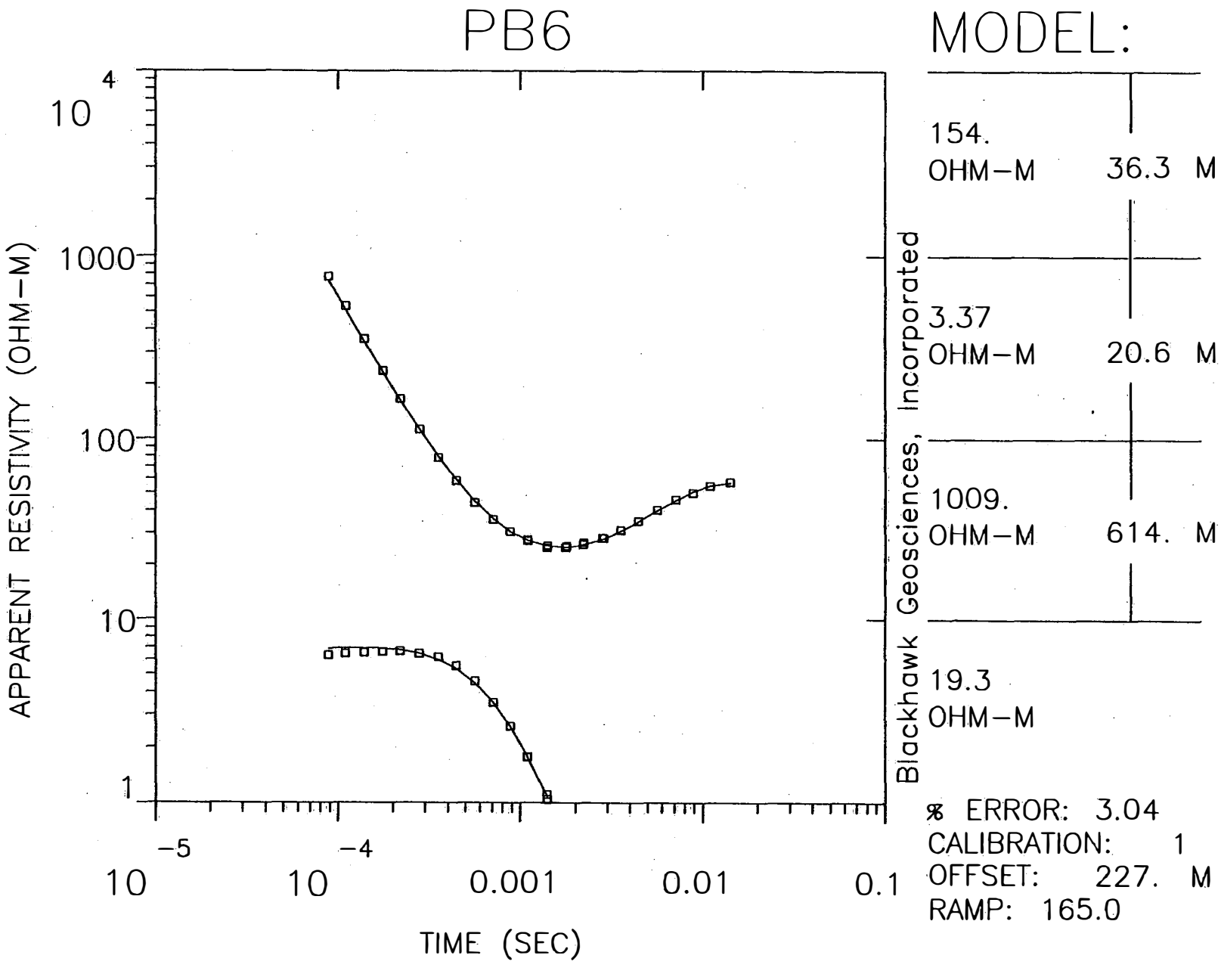
* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER
P 1 1.00

```
P 2   0.00   0.97
P 3   0.00  -0.01   1.00
T 1   0.00  -0.01   0.00   0.99
T 2   0.00   0.00   0.00   0.00   1.00
        P 1    P 2    P 3    T 1    T 2
```

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	48.739	51.148	54.885
	2	191.301	237.950	342.981
	3	4.658	5.589	7.095
THICK	1	74.444	85.916	105.944
	2	366.002	388.199	403.518
DEPTH	1	74.444	85.916	105.944
	2	466.903	474.115	480.594


PB6
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
154.
OHM-M
36.3 M
3.37
OHM-M
20.6 M
1009.
OHM-M
614. M
19.3
OHM-M
% ERROR: 3.04
CALIBRATION: 1
OFFSET: 227. M
RAMP: 165.0
Blackhawk Geosciences, Incorporated

PB6

MODEL: 4 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		362.1	1188.0		
153.52	36.3	325.8	1069.0	0.2	0.2
3.37	20.6	305.2	1001.4	6.1	6.3
1008.97	614.2	-309.0	-1013.8	0.6	7.0
19.29					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	7.72E+02	7.29E+02	5.928	
2	1.10E-04	5.34E+02	5.11E+02	4.588	
3	1.40E-04	3.54E+02	3.41E+02	3.813	
4	1.77E-04	2.38E+02	2.32E+02	2.701	
5	2.20E-04	1.65E+02	1.63E+02	1.159	
6	2.80E-04	1.13E+02	1.13E+02	-0.029	
7	3.55E-04	7.81E+01	7.98E+01	-2.059	
8	4.43E-04	5.82E+01	5.95E+01	-2.141	
9	5.64E-04	4.42E+01	4.49E+01	-1.681	
10	7.13E-04	3.57E+01	3.59E+01	-0.470	
11	8.81E-04	3.06E+01	3.07E+01	-0.115	
12	1.10E-03	2.75E+01	2.74E+01	0.491	
13	1.10E-03	2.72E+01	2.73E+01	-0.458	
14	1.40E-03	2.49E+01	2.55E+01	-2.033	
15	1.41E-03	2.56E+01	2.54E+01	0.844	
16	1.77E-03	2.49E+01	2.51E+01	-0.487	
17	1.80E-03	2.54E+01	2.51E+01	1.213	
18	2.20E-03	2.59E+01	2.58E+01	0.631	
19	2.22E-03	2.65E+01	2.58E+01	2.557	
20	2.80E-03	2.80E+01	2.77E+01	1.347	
21	2.85E-03	2.81E+01	2.79E+01	1.035	
22	3.55E-03	3.11E+01	3.07E+01	1.210	
23	4.43E-03	3.51E+01	3.46E+01	1.360	
24	5.64E-03	4.02E+01	3.99E+01	0.678	
25	7.13E-03	4.60E+01	4.58E+01	0.534	
26	8.81E-03	5.02E+01	5.10E+01	-1.498	
27	1.10E-02	5.48E+01	5.51E+01	-0.548	
28	1.41E-02	5.76E+01	5.72E+01	0.712	

R: 227. X: 0. Y: 228. DL: 455. REQ: 253. CF: 1.0000
CLHZ ARRAY, 28 DATA POINTS, RAMP: 165.0 MICROSEC, DATA: PB6
0807 PB 600WZ OPR XTL H 3 8 +100
Ch.21 = 0.165 Ch.22 = 0.089 Ch.23 = 11 Ch.24 =
RMS LOG ERROR: 1.30E-02, ANTILOG YIELDS 3.0402 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

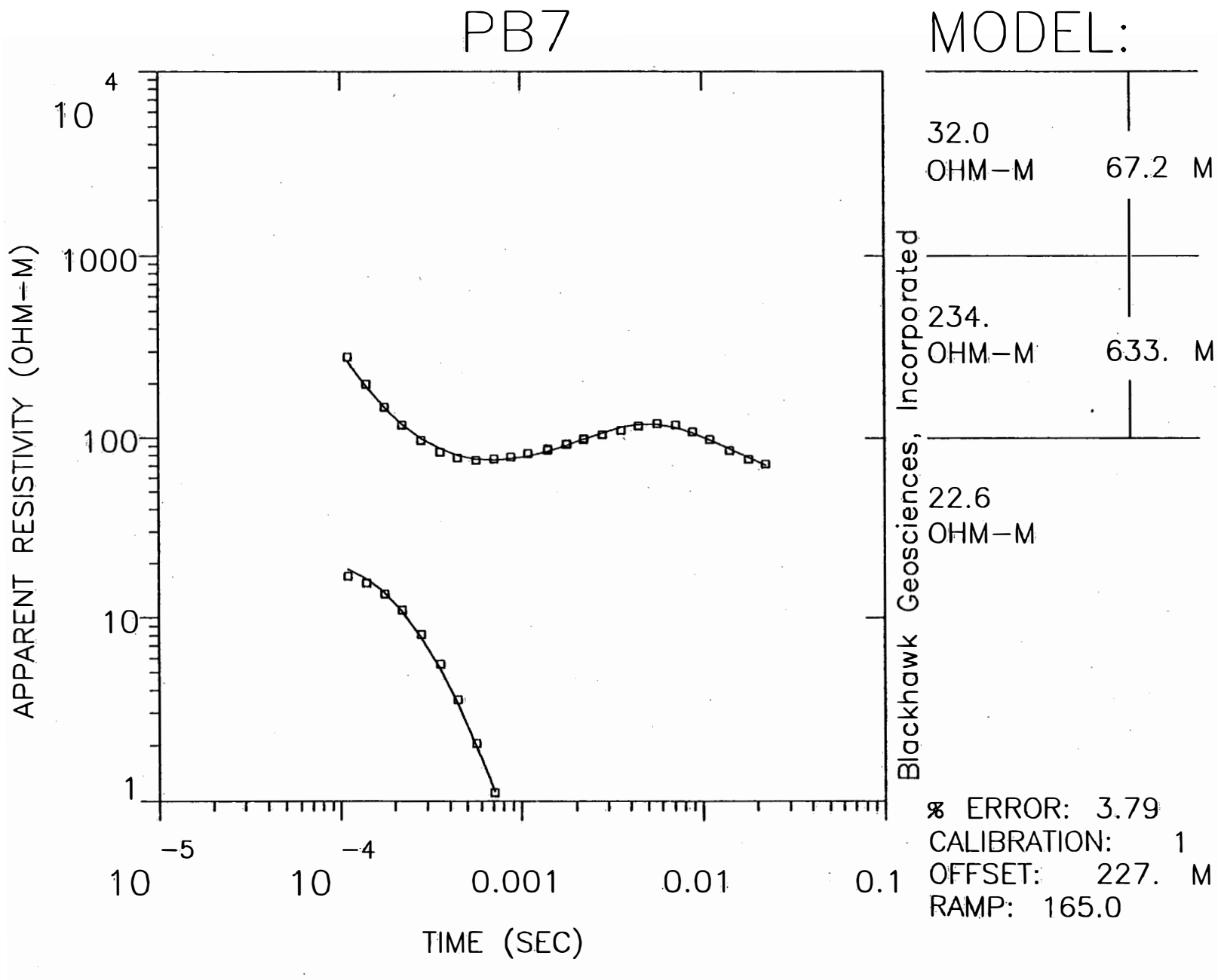
PARAMETER RESOLUTION MATRIX:

"F" MEANS FIXED PARAMETER

P 1	0.01						
P 2	0.01	0.65					
P 3	0.01	-0.03	0.02				
P 4	-0.01	0.05	-0.02	0.07			
T 1	0.05	0.17	0.01	-0.01	0.89		
T 2	-0.03	-0.36	-0.05	0.05	0.17	0.62	
T 3	0.01	-0.09	0.04	0.11	0.04	-0.10	0.93
	P 1	P 2	P 3	P 4	T 1	T 2	T 3

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	82.534	153.520	409.053
	2	2.765	3.371	4.299
	3	567.385	1008.970	3190.643
	4	8.979	19.289	49.920
THICK	1	32.147	36.261	39.953
	2	16.756	20.606	26.621
	3	549.097	614.243	672.192
DEPTH	1	32.147	36.261	39.953
	2	55.525	56.867	58.954
	3	605.362	671.109	729.595


PB7
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
32.0
OHM-M
67.2 M
234.
OHM-M
633. M
22.6
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 3.79
CALIBRATION: 1
OFFSET: 227. M
RAMP: 165.0

PB7

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	(FEET)	CONDUCTANCE (S) LAYER	TOTAL
		335.0	1099.0		
32.03	67.2	267.7	878.4	2.1	2.1
233.87	632.5	-364.8	-1196.9	2.7	4.8
22.62					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	1.10E-04	2.81E+02	2.65E+02	5.775	
2	1.40E-04	1.99E+02	1.93E+02	3.326	
3	1.77E-04	1.48E+02	1.47E+02	0.882	
4	2.20E-04	1.18E+02	1.19E+02	-1.156	
5	2.80E-04	9.69E+01	9.95E+01	-2.658	
6	3.55E-04	8.38E+01	8.74E+01	-4.064	
7	4.43E-04	7.79E+01	8.06E+01	-3.264	
8	5.64E-04	7.53E+01	7.67E+01	-1.879	
9	7.13E-04	7.66E+01	7.58E+01	1.087	
10	8.81E-04	7.85E+01	7.68E+01	2.192	
11	1.10E-03	8.22E+01	7.96E+01	3.240	
12	1.40E-03	8.58E+01	8.45E+01	1.501	
13	1.41E-03	8.71E+01	8.47E+01	2.851	
14	1.77E-03	9.26E+01	9.10E+01	1.710	
15	1.80E-03	9.30E+01	9.14E+01	1.714	
16	2.20E-03	9.83E+01	9.83E+01	-0.012	
17	2.22E-03	9.93E+01	9.87E+01	0.622	
18	2.80E-03	1.04E+02	1.07E+02	-2.499	
19	3.55E-03	1.10E+02	1.15E+02	-3.792	
20	4.43E-03	1.16E+02	1.19E+02	-2.364	
21	5.64E-03	1.20E+02	1.19E+02	0.886	
22	7.13E-03	1.18E+02	1.14E+02	3.073	
23	8.81E-03	1.08E+02	1.07E+02	1.290	
24	1.10E-02	9.83E+01	9.76E+01	0.752	
25	1.41E-02	8.51E+01	8.70E+01	-2.181	
26	1.80E-02	7.62E+01	7.78E+01	-2.021	
27	2.22E-02	7.16E+01	7.06E+01	1.382	

R: 227. X: 0. Y: 228. DL: 455. REQ: 253. CF: 1.0000
CLHZ ARRAY, 27 DATA POINTS, RAMP: 165.0 MICROSEC, DATA: PB7
0808 PB 700WZ OPR XTL L 6 8 +100 2
Ch.21 = 0.165 Ch.22 = 0.89 Ch.23 = 11 Ch.24 = 2
RMS LOG ERROR: 1.61E-02, ANTILOG YIELDS 3.7879 %
LATE TIME PARAMETERS

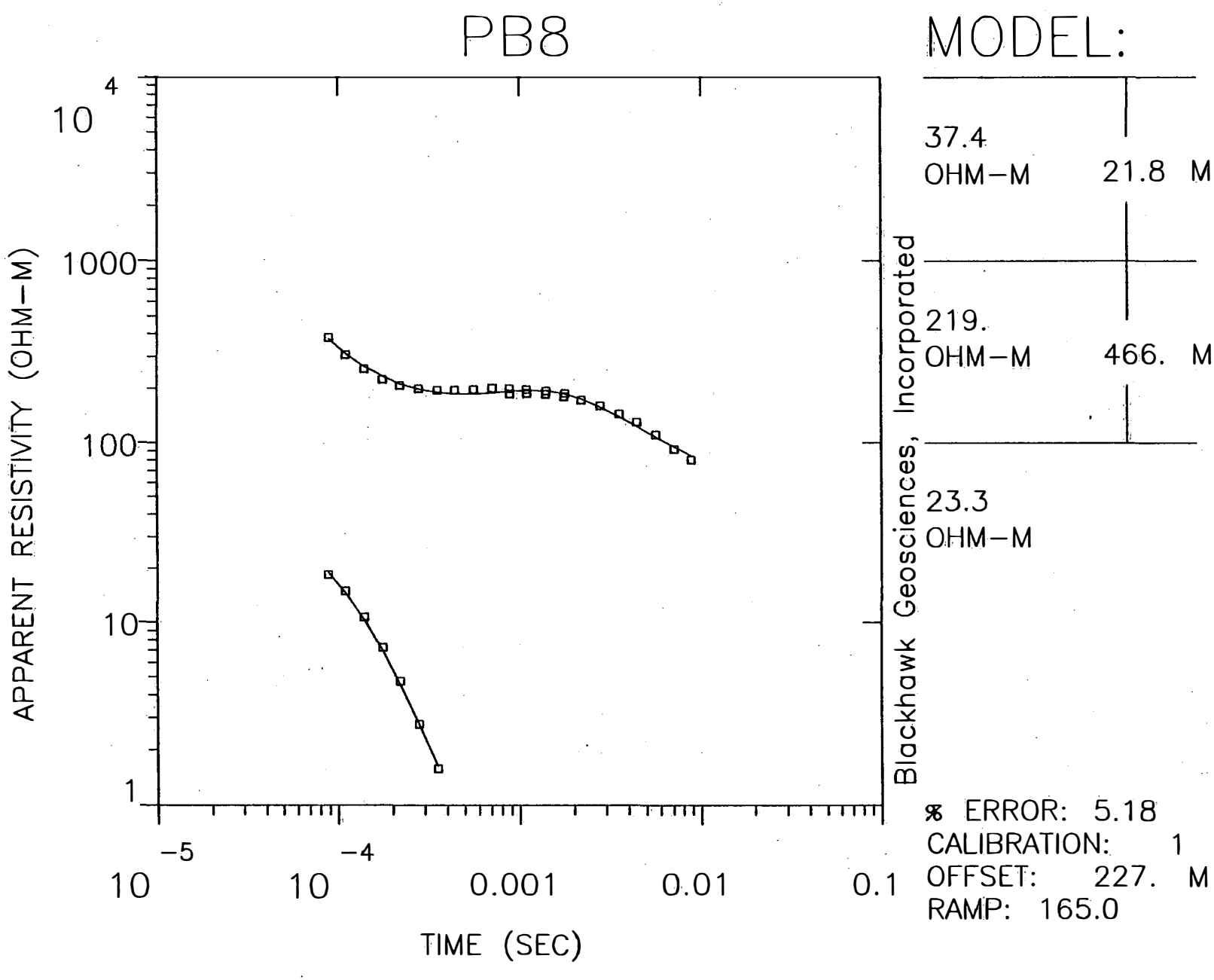
* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER
P 1 1.00

P 2	0.00	0.99			
P 3	0.00	0.00	0.99		
T 1	0.00	0.00	0.00	1.00	
T 2	0.00	0.00	0.00	0.00	1.00
	P 1	P 2	P 3	T 1	T 2

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	28.460	32.029	36.443
	2	189.047	233.874	307.897
	3	15.706	22.617	30.115
THICK	1	53.840	67.249	85.746
	2	571.088	632.534	693.244
DEPTH	1	53.840	67.249	85.746
	2	648.582	699.783	755.709


PB8
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
37.4
OHM-M
21.8 M
219.
OHM-M
466. M
23.3
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 5.18
CALIBRATION: 1
OFFSET: 227. M
RAMP: 165.0

PB8

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		392.0	1286.0		
37.40	21.8	370.2	1214.6	0.6	0.6
218.70	465.7	-95.5	-313.2	2.1	2.7
23.33					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	3.79E+02	3.73E+02	1.597	
2	1.10E-04	3.06E+02	3.11E+02	-1.560	
3	1.40E-04	2.55E+02	2.63E+02	-2.943	
4	1.77E-04	2.24E+02	2.32E+02	-3.522	
5	2.20E-04	2.08E+02	2.13E+02	-2.439	
6	2.80E-04	1.99E+02	1.99E+02	0.339	
7	3.55E-04	1.95E+02	1.90E+02	2.339	
8	4.43E-04	1.96E+02	1.87E+02	4.812	
9	5.64E-04	1.97E+02	1.86E+02	5.695	
10	7.13E-04	2.00E+02	1.89E+02	6.085	
11	8.81E-04	1.99E+02	1.92E+02	3.493	
12	8.90E-04	1.86E+02	1.92E+02	-2.969	
13	1.10E-03	1.97E+02	1.94E+02	1.202	
14	1.10E-03	1.87E+02	1.94E+02	-3.840	
15	1.40E-03	1.85E+02	1.93E+02	-4.386	
16	1.41E-03	1.92E+02	1.93E+02	-0.442	
17	1.77E-03	1.79E+02	1.86E+02	-3.720	
18	1.80E-03	1.87E+02	1.86E+02	0.748	
19	2.20E-03	1.71E+02	1.74E+02	-1.703	
20	2.80E-03	1.59E+02	1.57E+02	1.302	
21	3.55E-03	1.44E+02	1.39E+02	3.507	
22	4.43E-03	1.29E+02	1.23E+02	5.382	
23	5.64E-03	1.10E+02	1.07E+02	3.026	
24	7.13E-03	9.17E+01	9.43E+01	-2.729	
25	8.81E-03	8.04E+01	8.44E+01	-4.828	

R: 227. X: 0. Y: 228. DL: 455. REQ: 253. CF: 1.0000
CLHZ ARRAY, 25 DATA POINTS, RAMP: 165.0 MICROSEC, DATA: PB8
0808 PB 800WZ OPR XTL H 3 8 +100
Ch.21 = 0.165 Ch.22 = 0.089 Ch.23 = 11 Ch.24 =
RMS LOG ERROR: 2.20E-02, ANTILOG YIELDS 5.1844 %
LATE TIME PARAMETERS

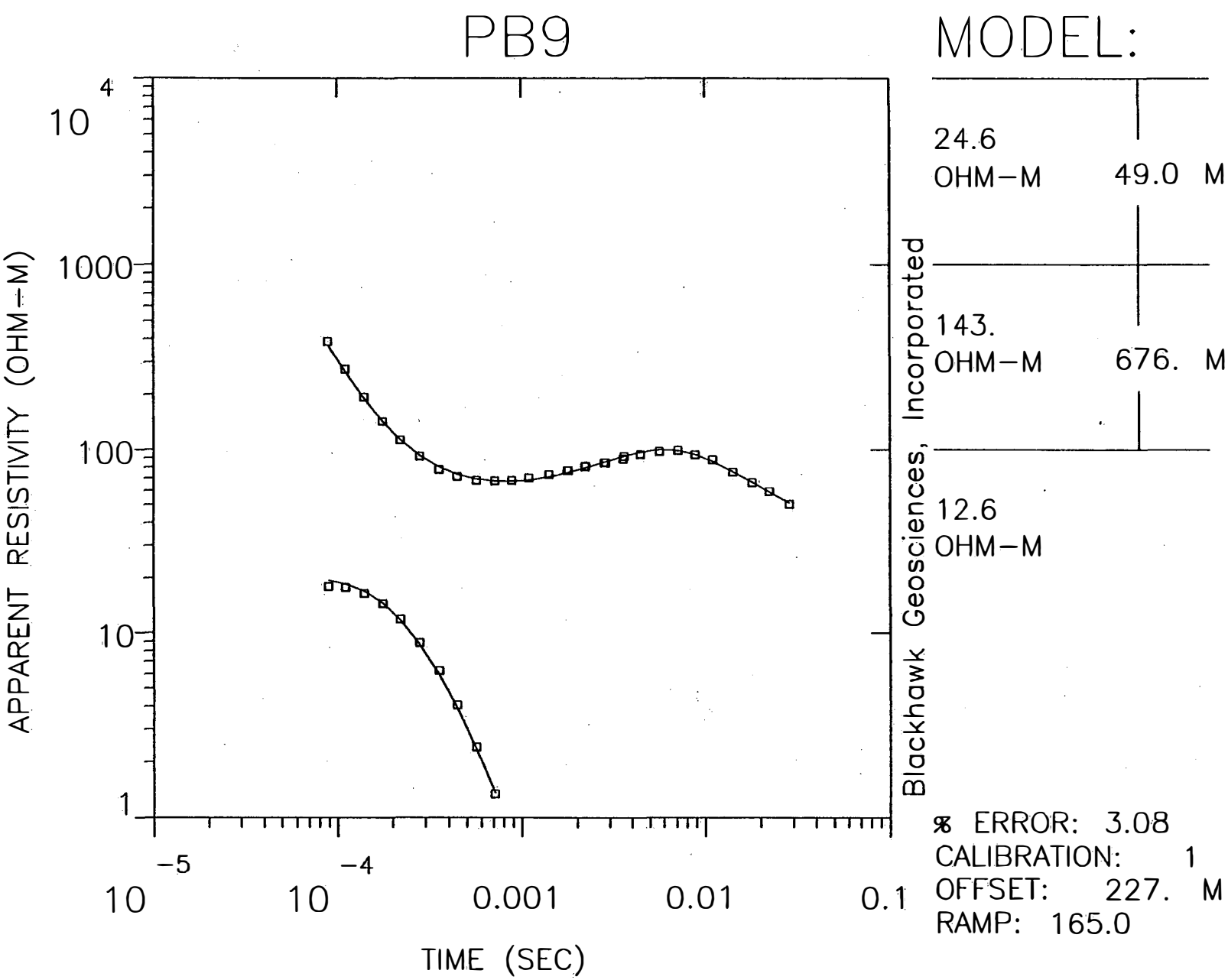
* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER
P 1 0.77
P 2 -0.04 0.98
P 3 -0.02 -0.03 0.89

```
T 1 -0.33 -0.08 -0.04  0.50
T 2  0.03  0.01  0.02  0.04  0.99
       P 1   P 2   P 3   T 1   T 2
```

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	21.445	37.401	61.509
	2	195.973	218.701	274.081
	3	16.640	23.334	33.894
THICK	1	9.720	21.757	46.146
	2	402.641	465.685	500.817
DEPTH	1	9.720	21.757	46.146
	2	448.787	487.442	515.756


PB9
MODEL:
APPARENT RESISTIVITY (OHM-M)
10 4
1000
100
10
1
10 -5
10 -4
0.001
0.01
0.1
TIME (SEC)
24.6
OHM-M
49.0 M
143.
OHM-M
676. M
12.6
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 3.08
CALIBRATION: 1
OFFSET: 227. M
RAMP: 165.0

PB9

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		341.1	1119.0		
24.63	49.0	292.1	958.4	2.0	2.0
142.73	676.3	-384.2	-1260.4	4.7	6.7
12.61					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	3.87E+02	3.68E+02	5.029	
2	1.10E-04	2.74E+02	2.66E+02	3.232	
3	1.40E-04	1.93E+02	1.89E+02	1.760	
4	1.77E-04	1.42E+02	1.42E+02	0.453	
5	2.20E-04	1.12E+02	1.13E+02	-0.832	
6	2.80E-04	9.16E+01	9.28E+01	-1.372	
7	3.55E-04	7.79E+01	8.04E+01	-3.025	
8	4.43E-04	7.15E+01	7.33E+01	-2.395	
9	5.64E-04	6.79E+01	6.89E+01	-1.500	
10	7.13E-04	6.77E+01	6.72E+01	0.742	
11	8.81E-04	6.80E+01	6.71E+01	1.352	
12	1.10E-03	6.99E+01	6.83E+01	2.327	
13	1.41E-03	7.30E+01	7.11E+01	2.651	
14	1.77E-03	7.66E+01	7.48E+01	2.445	
15	1.80E-03	7.69E+01	7.50E+01	2.450	
16	2.20E-03	8.05E+01	7.93E+01	1.529	
17	2.22E-03	8.14E+01	7.95E+01	2.324	
18	2.80E-03	8.49E+01	8.53E+01	-0.461	
19	2.85E-03	8.49E+01	8.57E+01	-0.942	
20	3.55E-03	8.91E+01	9.16E+01	-2.698	
21	3.60E-03	9.19E+01	9.20E+01	-0.034	
22	4.43E-03	9.42E+01	9.68E+01	-2.659	
23	5.64E-03	9.75E+01	9.99E+01	-2.388	
24	7.13E-03	9.91E+01	9.85E+01	0.598	
25	8.81E-03	9.38E+01	9.35E+01	0.234	
26	1.10E-02	8.78E+01	8.58E+01	2.250	
27	1.41E-02	7.55E+01	7.57E+01	-0.230	
28	1.80E-02	6.61E+01	6.64E+01	-0.346	
29	2.22E-02	5.94E+01	5.89E+01	0.822	
30	2.85E-02	5.05E+01	5.15E+01	-1.838	

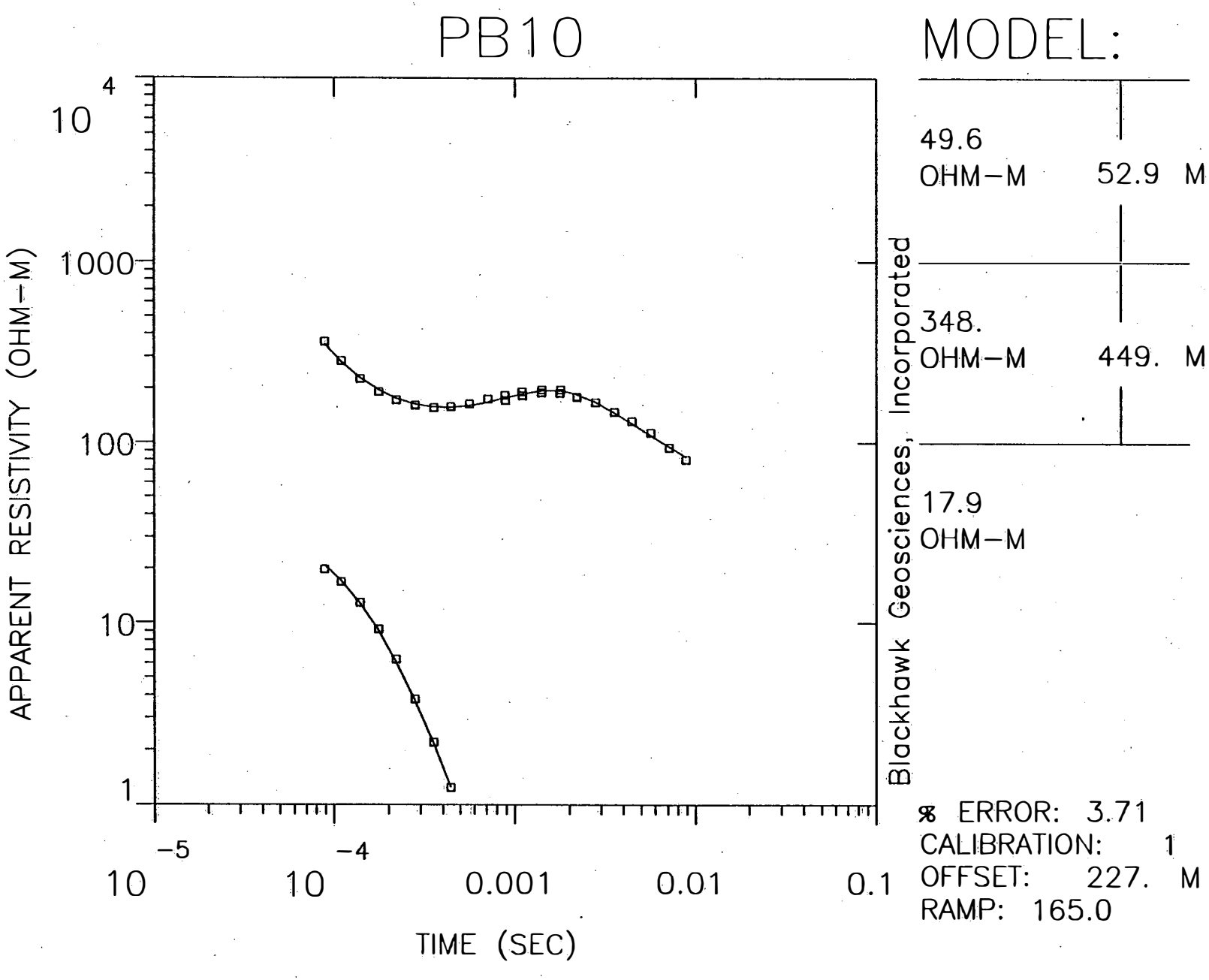
R: 227. X: 0. Y: 228. DL: 455. REQ: 253. CF: 1.0000
CLHZ ARRAY, 30 DATA POINTS, RAMP: 165.0 MICROSEC, DATA: PB9
0808 PB 900WZ OPR XTL L 6 8 +100
Ch.21 = 0.165 Ch.22 = 0.89 Ch.23 = 11 Ch.24 = 2
RMS LOG ERROR: 1.32E-02, ANTILOG YIELDS 3.0807 %
LATE TIME PARAMETERS

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.96				
P 2	-0.02	0.96			
P 3	-0.01	-0.04	0.78		
T 1	-0.06	-0.05	-0.03	0.89	
T 2	0.01	0.01	0.03	0.02	0.99
	P 1	P 2	P 3	T 1	T 2

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	20.550	24.631	28.670
	2	128.828	142.732	164.391
	3	9.303	12.609	17.088
THICK	1	36.916	48.950	63.301
	2	626.106	676.292	713.116
DEPTH	1	36.916	48.950	63.301
	2	682.807	725.242	757.361


PB10
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
49.6
OHM-M
52.9 M
348.
OHM-M
449. M
17.9
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 3.71
CALIBRATION: 1
OFFSET: 227. M
RAMP: 165.0

PB10

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		458.1	1503.0		
49.62	52.9	405.3	1329.6	1.1	1.1
347.97	449.3	-44.0	-144.5	1.3	2.4
17.87					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	3.62E+02	3.48E+02	3.783	
2	1.10E-04	2.82E+02	2.79E+02	0.971	
3	1.40E-04	2.25E+02	2.27E+02	-0.870	
4	1.77E-04	1.91E+02	1.95E+02	-1.746	
5	2.20E-04	1.71E+02	1.75E+02	-2.214	
6	2.80E-04	1.61E+02	1.63E+02	-1.241	
7	3.55E-04	1.55E+02	1.57E+02	-0.898	
8	4.43E-04	1.57E+02	1.56E+02	0.786	
9	5.64E-04	1.63E+02	1.60E+02	2.084	
10	7.13E-04	1.74E+02	1.67E+02	4.164	
11	8.81E-04	1.82E+02	1.76E+02	3.590	
12	8.90E-04	1.71E+02	1.77E+02	-3.321	
13	1.10E-03	1.91E+02	1.86E+02	2.696	
14	1.10E-03	1.81E+02	1.86E+02	-2.647	
15	1.40E-03	1.88E+02	1.94E+02	-2.748	
16	1.41E-03	1.96E+02	1.94E+02	0.955	
17	1.77E-03	1.88E+02	1.93E+02	-3.011	
18	1.80E-03	1.95E+02	1.93E+02	0.940	
19	2.20E-03	1.79E+02	1.84E+02	-3.115	
20	2.80E-03	1.67E+02	1.67E+02	-0.063	
21	3.55E-03	1.47E+02	1.46E+02	0.586	
22	4.43E-03	1.31E+02	1.28E+02	2.854	
23	5.64E-03	1.13E+02	1.09E+02	3.478	
24	7.13E-03	9.37E+01	9.43E+01	-0.662	
25	8.81E-03	8.01E+01	8.30E+01	-3.466	

R: 227. X: 0. Y: 228. DL: 455. REQ: 253. CF: 1.0000
CLHZ ARRAY, 25 DATA POINTS, RAMP: 165.0 MICROSEC, DATA: PB10
0908 PB 1000WZ OPR XTL H 3 8 +100
Ch.21 = 0.165 Ch.22 = 0.089 Ch.23 = 11 Ch.24 =
RMS LOG ERROR: 1.58E-02, ANTILOG YIELDS 3.7088 %
LATE TIME PARAMETERS

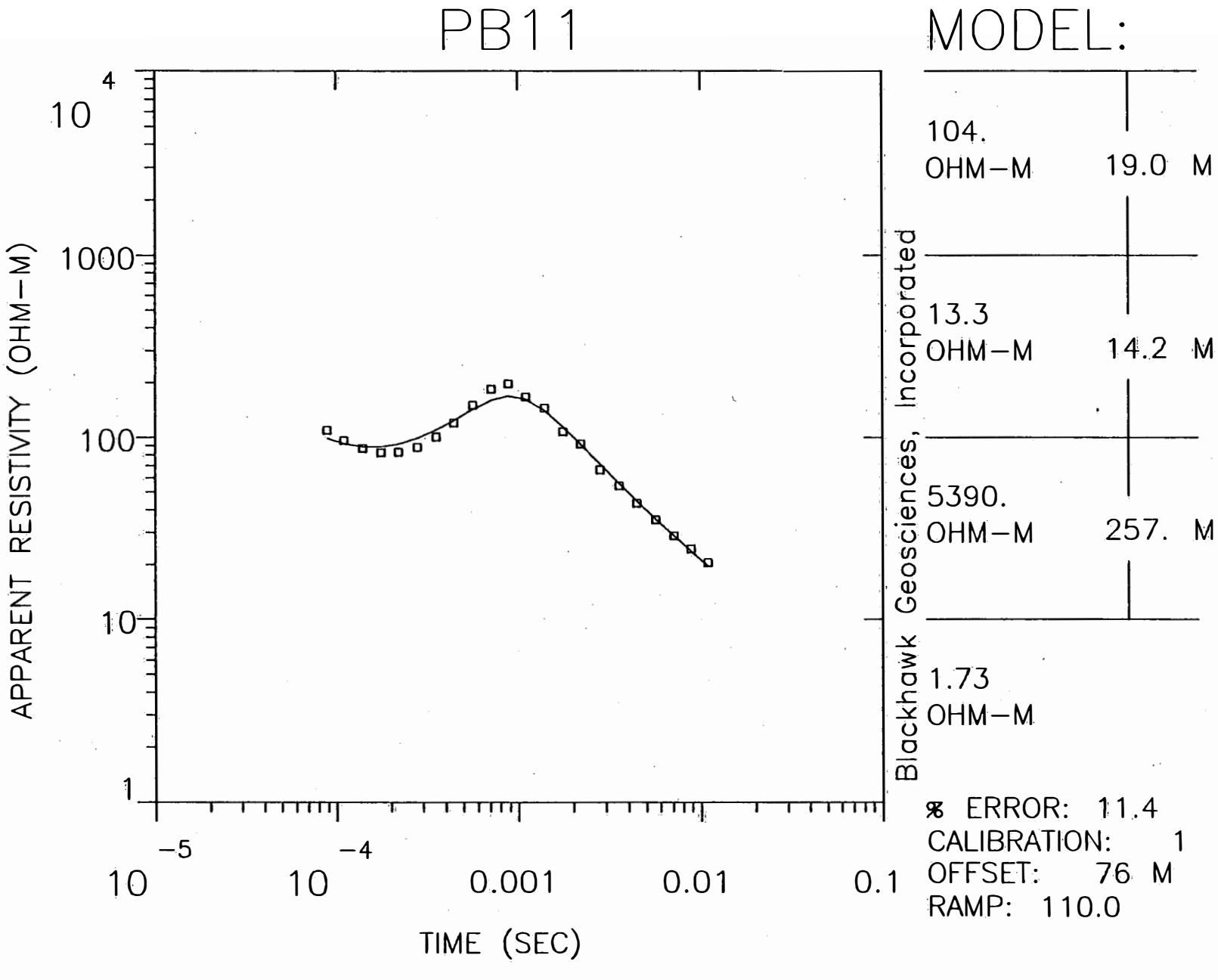
* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER
P 1 0.92
P 2 -0.10 0.71
P 3 0.00 -0.10 0.80

```
T 1 -0.14 -0.24 -0.03  0.72
T 2  0.02  0.05  0.03  0.05  0.99
       P 1   P 2   P 3   T 1   T 2
```

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	41.871	49.624	61.432
	2	277.377	347.966	473.401
	3	12.906	17.866	24.011
THICK	1	38.994	52.854	77.455
	2	416.903	449.295	474.625
DEPTH	1	38.994	52.854	77.455
	2	485.688	502.149	521.387


PB11
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
104.
OHM-M
19.0 M
13.3
OHM-M
14.2 M
5390.
OHM-M
257. M
1.73
OHM-M
% ERROR: 11.4
CALIBRATION: 1
OFFSET: 76 M
RAMP: 110.0
Blackhawk Geosciences, Incorporated

PB11

MODEL: 4 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		260.0	853.0		
104.21	19.0	240.9	790.5	0.2	0.2
13.29	14.2	226.8	744.1	1.1	1.2
5389.87	256.7	-29.9	-98.2	0.0	1.3
1.73					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	1.09E+02	9.83E+01	11.082	
2	1.10E-04	9.57E+01	9.21E+01	4.006	
3	1.40E-04	8.70E+01	8.86E+01	-1.826	
4	1.77E-04	8.24E+01	8.87E+01	-7.105	
5	2.20E-04	8.24E+01	9.17E+01	-10.065	
6	2.80E-04	8.82E+01	9.84E+01	-10.423	
7	3.55E-04	9.98E+01	1.09E+02	-8.527	
8	4.43E-04	1.20E+02	1.23E+02	-2.792	
9	5.64E-04	1.50E+02	1.42E+02	5.372	
10	7.13E-04	1.83E+02	1.60E+02	14.590	
11	8.81E-04	1.97E+02	1.68E+02	16.826	
12	1.10E-03	1.67E+02	1.62E+02	3.237	
13	1.40E-03	1.45E+02	1.40E+02	3.592	
14	1.77E-03	1.07E+02	1.13E+02	-5.663	
15	2.20E-03	9.19E+01	9.12E+01	0.693	
16	2.80E-03	6.64E+01	7.14E+01	-6.997	
17	3.55E-03	5.40E+01	5.61E+01	-3.686	
18	4.43E-03	4.33E+01	4.50E+01	-3.746	
19	5.64E-03	3.53E+01	3.56E+01	-0.860	
20	7.13E-03	2.88E+01	2.86E+01	0.669	
21	8.81E-03	2.44E+01	2.36E+01	3.317	
22	1.10E-02	2.06E+01	1.96E+01	5.112	

R: 76. X: 0. Y: 76. DL: 152. REQ: 84. CF: 1.0000
CLHZ ARRAY, 22 DATA POINTS, RAMP: 110.0 MICROSEC, DATA: PB11
0908 PB 1100WZ OPR XTL L 6 8 +100
Ch.21 = 0.11 Ch.22 = 0.89 Ch.23 = 18 Ch.24 = 23
RMS LOG ERROR: 4.68E-02, ANTILOG YIELDS 11.3731 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

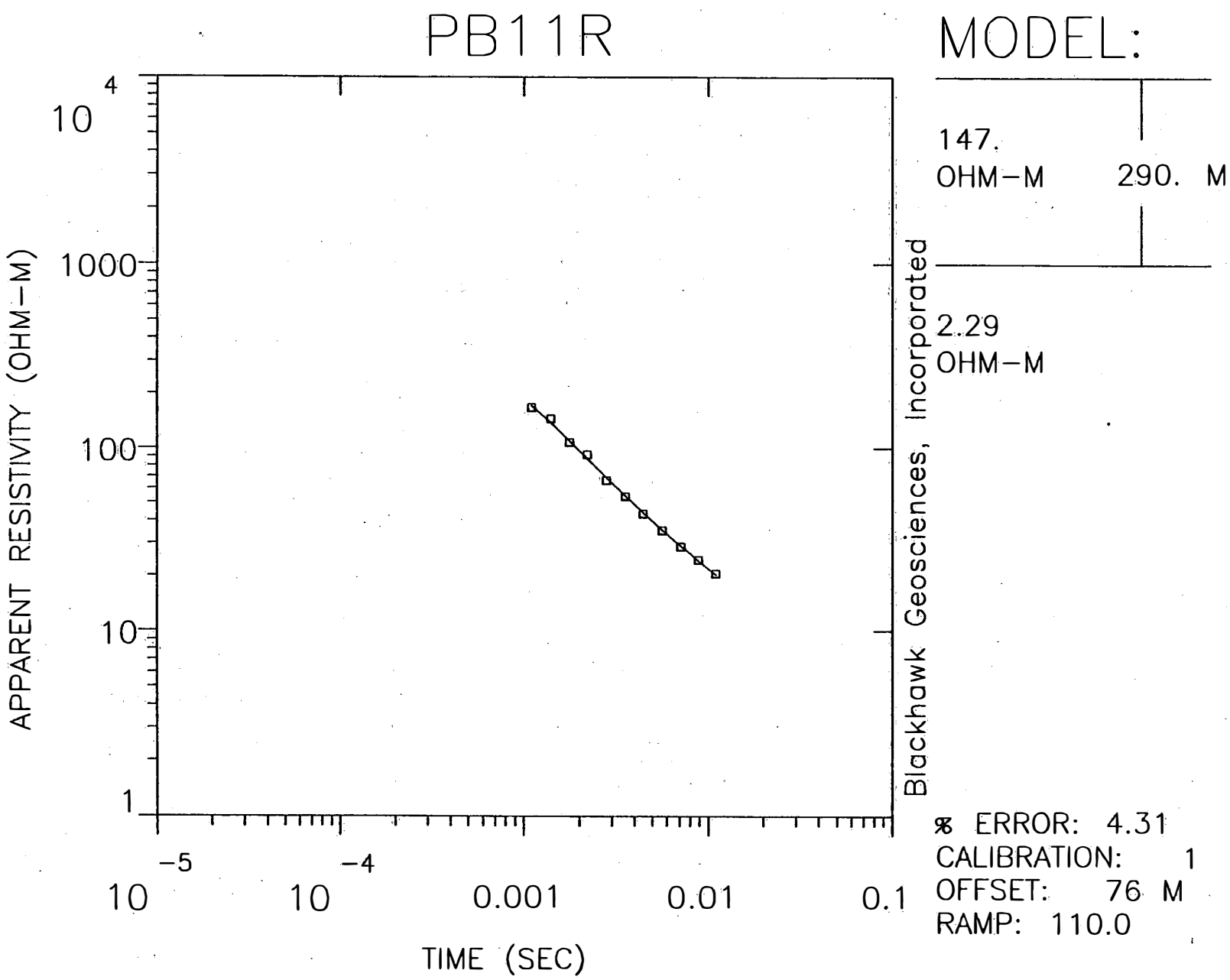
PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.02				
P 2	0.09	0.53			
P 3	0.00	0.00	0.00		
P 4	0.00	0.01	0.00	0.08	
T 1	0.01	0.03	0.00	0.02	0.09

```
T 2 -0.07 -0.45 -0.01  0.04  0.05  0.46
T 3  0.00  0.02  0.00 -0.02  0.06  0.01  0.95
       P 1   P 2   P 3   P 4   T 1   T 2   T 3
```

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	58.603	104.212	245.227
	2	6.383	13.289	21.345
	3	1704.426	5389.869	53898.687
	4	0.768	1.728	2.889
THICK	1	8.154	19.046	28.754
	2	6.996	14.160	25.130
	3	246.307	256.711	270.602
DEPTH	1	8.154	19.046	28.754
	2	22.925	33.206	43.286
	3	280.608	289.917	300.904


PB11R
MODEL:
147.
OHM-M
290. M
2.29
OHM-M
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
Blackhawk Geosciences, Incorporated
% ERROR: 4.31
CALIBRATION: 1
OFFSET: 76 M
RAMP: 110.0

PB11R

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		260.0	853.0		
146.95	289.7	-29.7	-97.5	2.0	2.0
2.29					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	1.10E-03	1.67E+02	1.71E+02	-2.481	
2	1.40E-03	1.45E+02	1.37E+02	5.450	
3	1.77E-03	1.07E+02	1.09E+02	-1.744	
4	2.20E-03	9.19E+01	8.76E+01	4.906	
5	2.80E-03	6.64E+01	6.89E+01	-3.729	
6	3.55E-03	5.40E+01	5.47E+01	-1.345	
7	4.43E-03	4.33E+01	4.44E+01	-2.401	
8	5.64E-03	3.53E+01	3.55E+01	-0.646	
9	7.13E-03	2.88E+01	2.89E+01	-0.331	
10	8.81E-03	2.44E+01	2.41E+01	1.090	
11	1.10E-02	2.06E+01	2.02E+01	1.649	

R: 76. X: 0. Y: 76. DL: 152. REQ: 84. CF: 1.0000
CLHZ ARRAY, 11 DATA POINTS, RAMP: 110.0 MICROSEC, DATA: PB11R
0908 PB 1100WZ OPR XTL L 6 8 +100
Ch.21 = 0.11 Ch.22 = 0.89 Ch.23 = 18 Ch.24 = 23
RMS LOG ERROR: 1.83E-02, ANTILOG YIELDS 4.3105 %
LATE TIME PARAMETERS

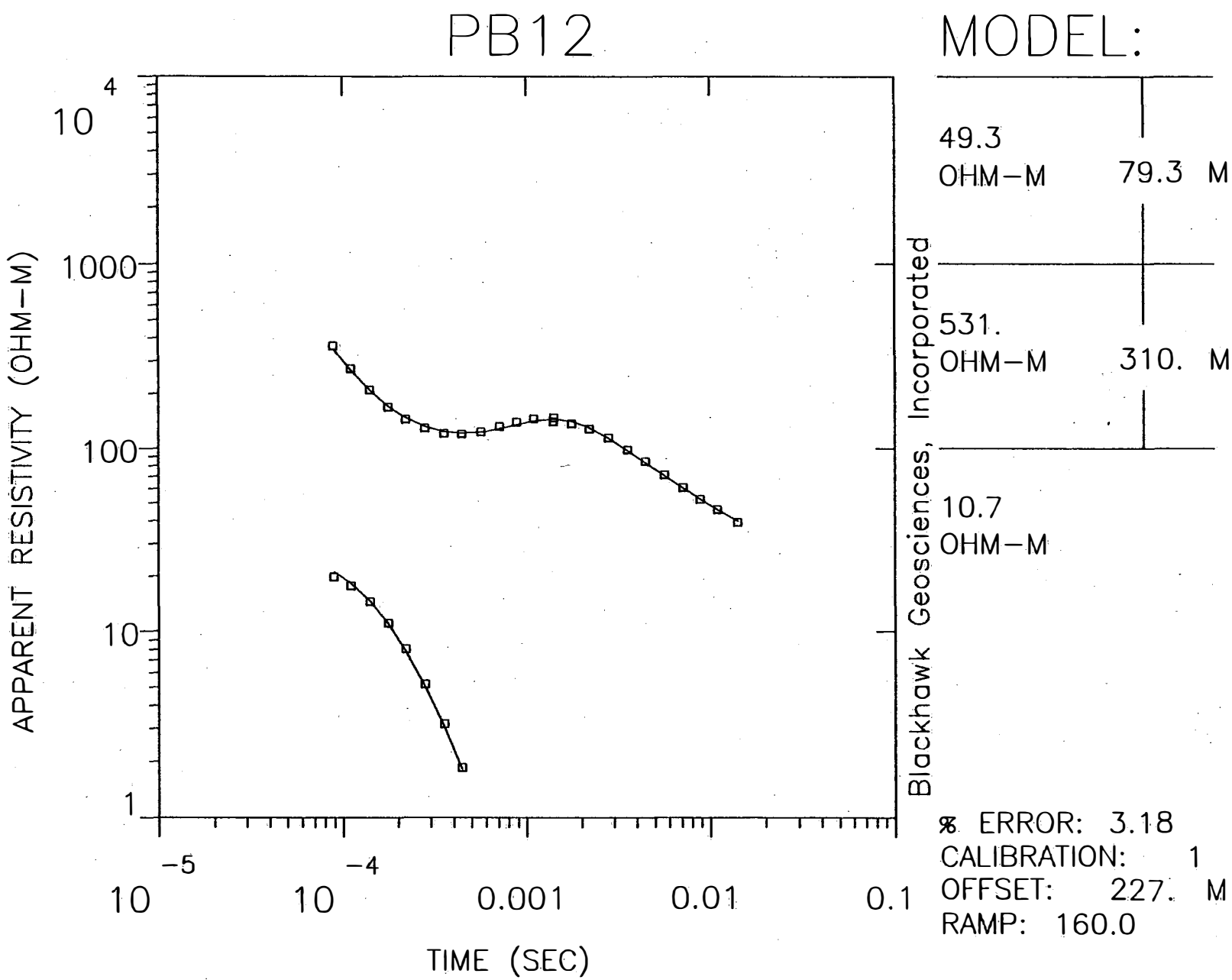
* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.99		
P 2	0.00	0.99	
T 1	0.00	0.00	1.00
	P 1	P 2	T 1

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	119.872	146.952	211.611
	2	1.806	2.286	2.944
THICK	1	283.799	289.720	294.351
DEPTH	1	283.799	289.720	294.351


PB12
MODEL:
APPARENT RESISTIVITY (OHM-M)
10 4
1000
100
10
1
10 -5
10 -4
0.001
0.01
0.1
TIME (SEC)
Blackhawk Geosciences, Incorporated
49.3
OHM-M
79.3 M
531.
OHM-M
310. M
10.7
OHM-M
% ERROR: 3.18
CALIBRATION: 1
OFFSET: 227. M
RAMP: 160.0

PB12

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		417.9	1371.0		
49.35	79.3	338.5	1110.7	1.6	1.6
530.76	309.8	28.7	94.2	0.6	2.2
10.66					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	3.62E+02	3.46E+02	4.559	
2	1.10E-04	2.73E+02	2.67E+02	1.974	
3	1.40E-04	2.08E+02	2.08E+02	0.329	
4	1.77E-04	1.69E+02	1.70E+02	-1.012	
5	2.20E-04	1.45E+02	1.48E+02	-2.117	
6	2.80E-04	1.29E+02	1.32E+02	-2.024	
7	3.55E-04	1.21E+02	1.24E+02	-2.446	
8	4.43E-04	1.20E+02	1.21E+02	-1.138	
9	5.64E-04	1.23E+02	1.23E+02	0.310	
10	7.13E-04	1.32E+02	1.28E+02	3.201	
11	8.81E-04	1.39E+02	1.35E+02	3.347	
12	1.10E-03	1.45E+02	1.41E+02	2.783	
13	1.40E-03	1.40E+02	1.45E+02	-3.272	
14	1.41E-03	1.47E+02	1.45E+02	1.374	
15	1.77E-03	1.36E+02	1.41E+02	-3.146	
16	2.20E-03	1.28E+02	1.30E+02	-1.971	
17	2.80E-03	1.14E+02	1.14E+02	0.288	
18	3.55E-03	9.82E+01	9.75E+01	0.759	
19	4.43E-03	8.49E+01	8.35E+01	1.626	
20	5.64E-03	7.14E+01	7.06E+01	1.181	
21	7.13E-03	6.09E+01	6.03E+01	0.984	
22	8.81E-03	5.25E+01	5.26E+01	-0.215	
23	1.10E-02	4.60E+01	4.61E+01	-0.154	
24	1.41E-02	3.93E+01	3.99E+01	-1.498	

R: 227. X: 0. Y: 228. DL: 455. REQ: 253. CF: 1.0000
CLHZ ARRAY, 24 DATA POINTS, RAMP: 160.0 MICROSEC, DATA: PB12
1008 PB 1200WZ OPR XTL L 5 8 +100
Ch.21 = 0.16 Ch.22 = 0.89 Ch.23 = 11 Ch.24 = 20
RMS LOG ERROR: 1.36E-02, ANTILOG YIELDS 3.1795 %
LATE TIME PARAMETERS

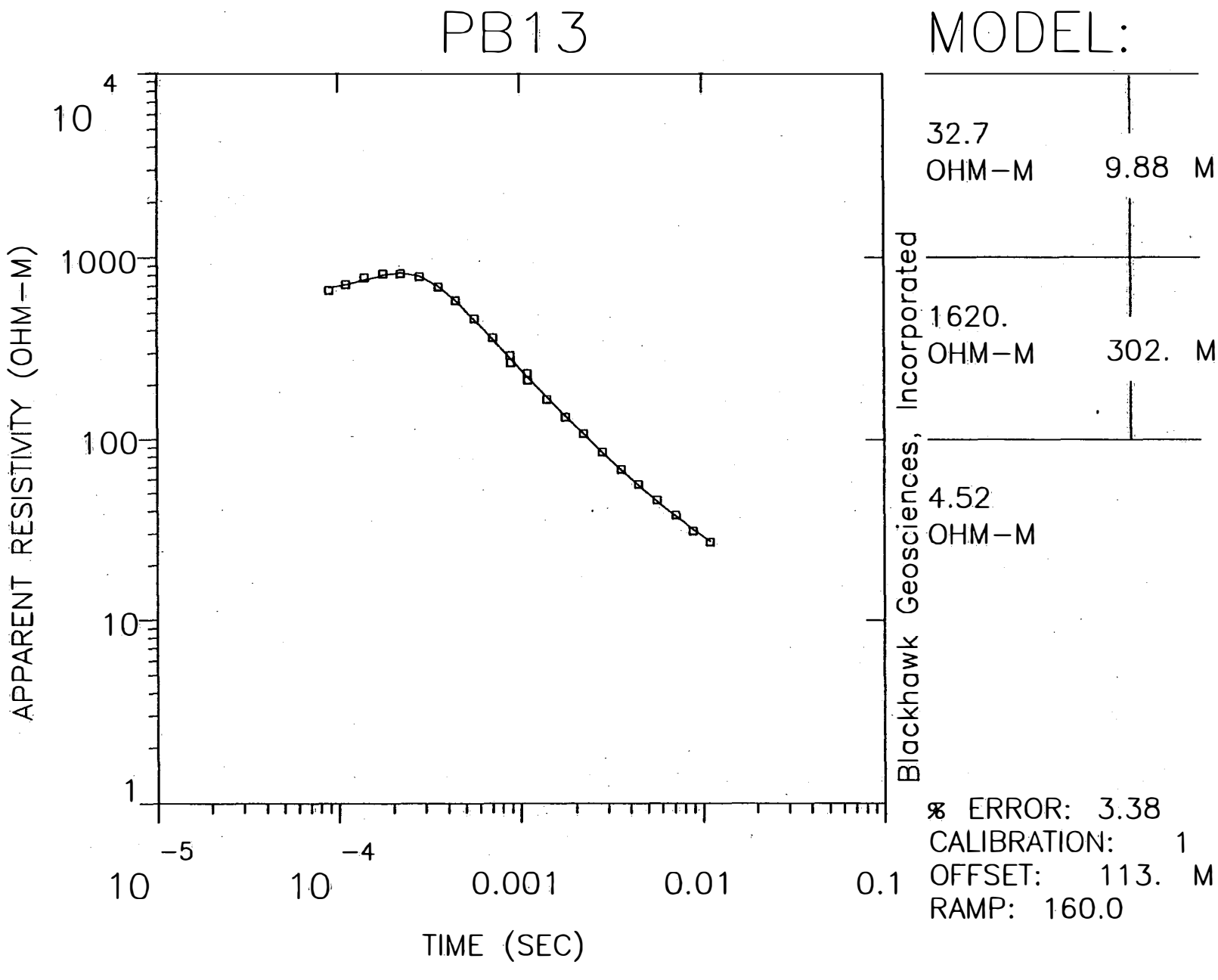
* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER
P 1 0.98
P 2 -0.03 0.09
P 3 0.01 -0.04 0.92
T 1 -0.03 -0.15 0.02 0.93

```
T 2  0.00  0.06  0.01  0.01  0.99
       P 1   P 2   P 3   T 1   T 2
```

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	43.650	49.349	54.059
	2	324.955	530.759	940.683
	3	9.228	10.663	12.612
THICK	1	64.701	79.344	93.352
	2	292.380	309.829	328.408
DEPTH	1	64.701	79.344	93.352
	2	379.985	389.173	399.472


PB13
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
32.7
OHM-M
9.88 M
1620.
OHM-M
302. M
4.52
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 3.38
CALIBRATION: 1
OFFSET: 113. M
RAMP: 160.0

PB13

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		289.0	948.0		
32.73	9.9	279.1	915.6	0.3	0.3
1620.43	301.7	-22.7	-74.3	0.2	0.5
4.52					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	6.64E+02	6.84E+02	-2.953	
2	1.10E-04	7.14E+02	7.13E+02	0.036	
3	1.40E-04	7.79E+02	7.58E+02	2.665	
4	1.77E-04	8.16E+02	8.03E+02	1.541	
5	2.20E-04	8.20E+02	8.24E+02	-0.531	
6	2.80E-04	7.86E+02	7.94E+02	-1.050	
7	3.55E-04	6.91E+02	7.01E+02	-1.436	
8	4.43E-04	5.83E+02	5.83E+02	-0.041	
9	5.64E-04	4.64E+02	4.57E+02	1.457	
10	7.13E-04	3.65E+02	3.55E+02	2.812	
11	8.81E-04	2.91E+02	2.82E+02	3.387	
12	8.90E-04	2.66E+02	2.78E+02	-4.556	
13	1.10E-03	2.32E+02	2.22E+02	4.453	
14	1.10E-03	2.13E+02	2.21E+02	-3.581	
15	1.40E-03	1.67E+02	1.71E+02	-2.724	
16	1.77E-03	1.32E+02	1.34E+02	-1.439	
17	2.20E-03	1.07E+02	1.08E+02	-0.259	
18	2.80E-03	8.53E+01	8.52E+01	0.168	
19	3.55E-03	6.85E+01	6.82E+01	0.510	
20	4.43E-03	5.66E+01	5.59E+01	1.279	
21	5.64E-03	4.61E+01	4.54E+01	1.588	
22	7.13E-03	3.81E+01	3.75E+01	1.483	
23	8.81E-03	3.12E+01	3.19E+01	-2.131	
24	1.10E-02	2.70E+01	2.72E+01	-0.637	

R: 113. X: 0. Y: 114. DL: 227. REQ: 127. CF: 1.0000
CLHZ ARRAY, 24 DATA POINTS, RAMP: 160.0 MICROSEC, DATA: PB13
1008 PB 1300WZ OPR XTL H 4 8 +100
Ch.21 = 0.14 Ch.22 = 0.089 Ch.23 = 17 Ch.24 = 5
RMS LOG ERROR: 1.44E-02, ANTILOG YIELDS 3.3824 %
LATE TIME PARAMETERS

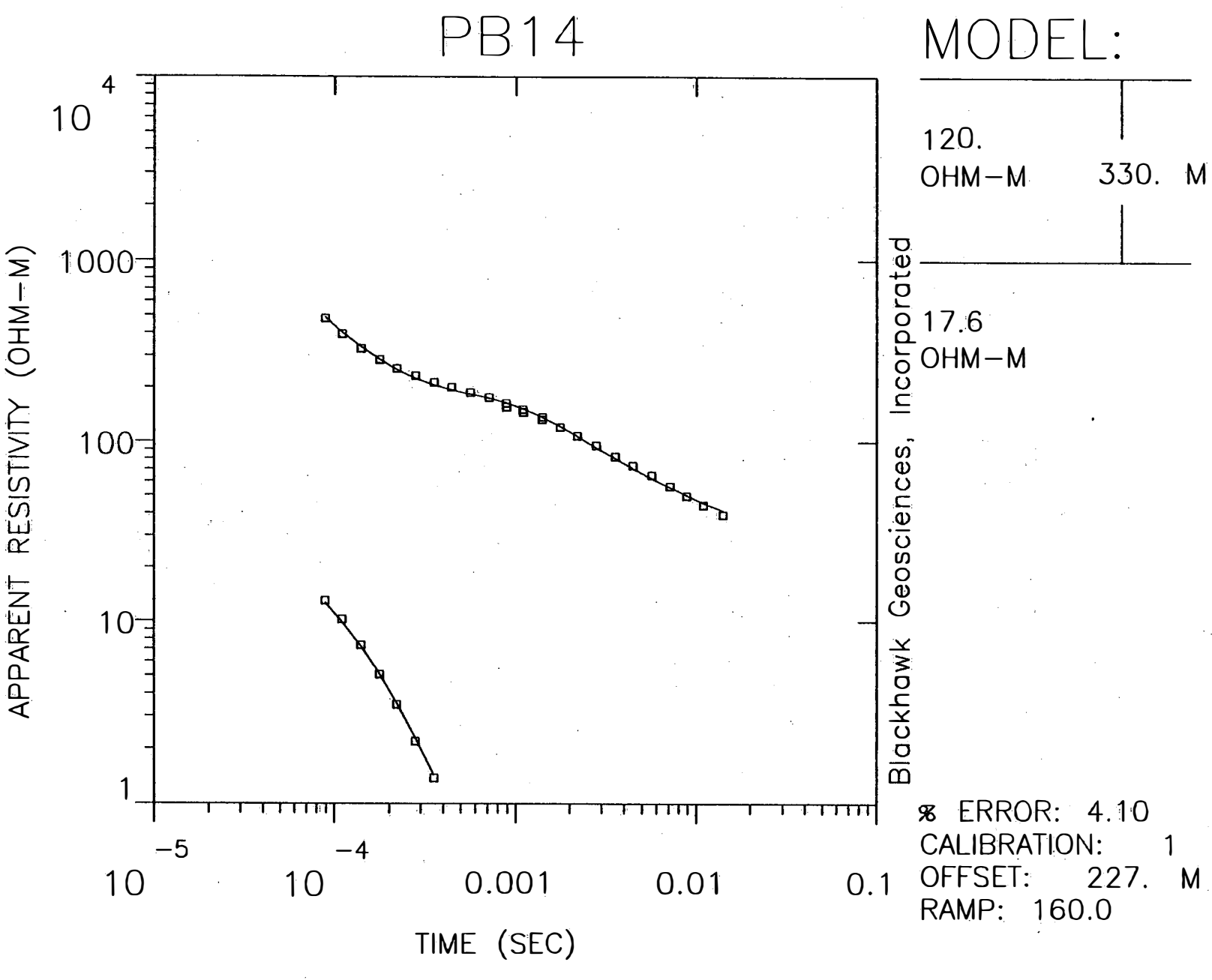
* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER
P 1 0.66
P 2 -0.04 0.12
P 3 0.04 -0.04 0.91
T 1 -0.34 -0.19 0.04 0.62

T 2 0.01 0.01 0.00 0.01 1.00
P 1 P 2 P 3 T 1 T 2

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	22.187	32.727	45.363
	2	1158.703	1620.427	2670.875
	3	4.031	4.521	5.071
THICK	1	6.647	9.875	14.148
	2	296.672	301.725	305.837
DEPTH	1	6.647	9.875	14.148
	2	308.517	311.600	314.372


PB14
MODEL:
120.
OHM-M
330. M
17.6
OHM-M
% ERROR: 4.10
CALIBRATION: 1
OFFSET: 227. M
RAMP: 160.0
Blackhawk Geosciences, Incorporated
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)

PB14

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		319.1	1047.0		
119.81	329.8	-10.6	-34.9	2.8	2.8
17.57					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	4.78E+02	4.87E+02	-1.844	
2	1.10E-04	3.94E+02	4.03E+02	-2.365	
3	1.40E-04	3.28E+02	3.33E+02	-1.593	
4	1.77E-04	2.84E+02	2.85E+02	-0.030	
5	2.20E-04	2.55E+02	2.51E+02	1.319	
6	2.80E-04	2.32E+02	2.25E+02	3.170	
7	3.55E-04	2.13E+02	2.06E+02	3.044	
8	4.43E-04	2.00E+02	1.94E+02	3.198	
9	5.64E-04	1.87E+02	1.84E+02	1.922	
10	7.13E-04	1.76E+02	1.74E+02	1.114	
11	8.81E-04	1.64E+02	1.65E+02	-0.711	
12	8.90E-04	1.56E+02	1.64E+02	-5.105	
13	1.10E-03	1.51E+02	1.53E+02	-1.109	
14	1.10E-03	1.45E+02	1.52E+02	-4.789	
15	1.40E-03	1.32E+02	1.37E+02	-3.340	
16	1.41E-03	1.37E+02	1.36E+02	0.054	
17	1.77E-03	1.20E+02	1.21E+02	-1.002	
18	2.20E-03	1.08E+02	1.07E+02	0.587	
19	2.80E-03	9.50E+01	9.29E+01	2.345	
20	3.55E-03	8.29E+01	8.08E+01	2.536	
21	4.43E-03	7.37E+01	7.13E+01	3.356	
22	5.64E-03	6.52E+01	6.26E+01	4.085	
23	7.13E-03	5.66E+01	5.56E+01	1.780	
24	8.81E-03	5.00E+01	5.03E+01	-0.725	
25	1.10E-02	4.45E+01	4.57E+01	-2.612	
26	1.41E-02	3.93E+01	4.13E+01	-4.798	

R: 227. X: 0. Y: 228. DL: 455. REQ: 253. CF: 1.0000
CLHZ ARRAY, 26 DATA POINTS, RAMP: 160.0 MICROSEC, DATA: PB14
1008 PB 1400WZ OPR XTL H 3 8 +100
Ch.21 = 0.16 Ch.22 = 0.089 Ch.23 = 11 Ch.24 = 2
RMS LOG ERROR: 1.74E-02, ANTILOG YIELDS 4.0998 %
LATE TIME PARAMETERS

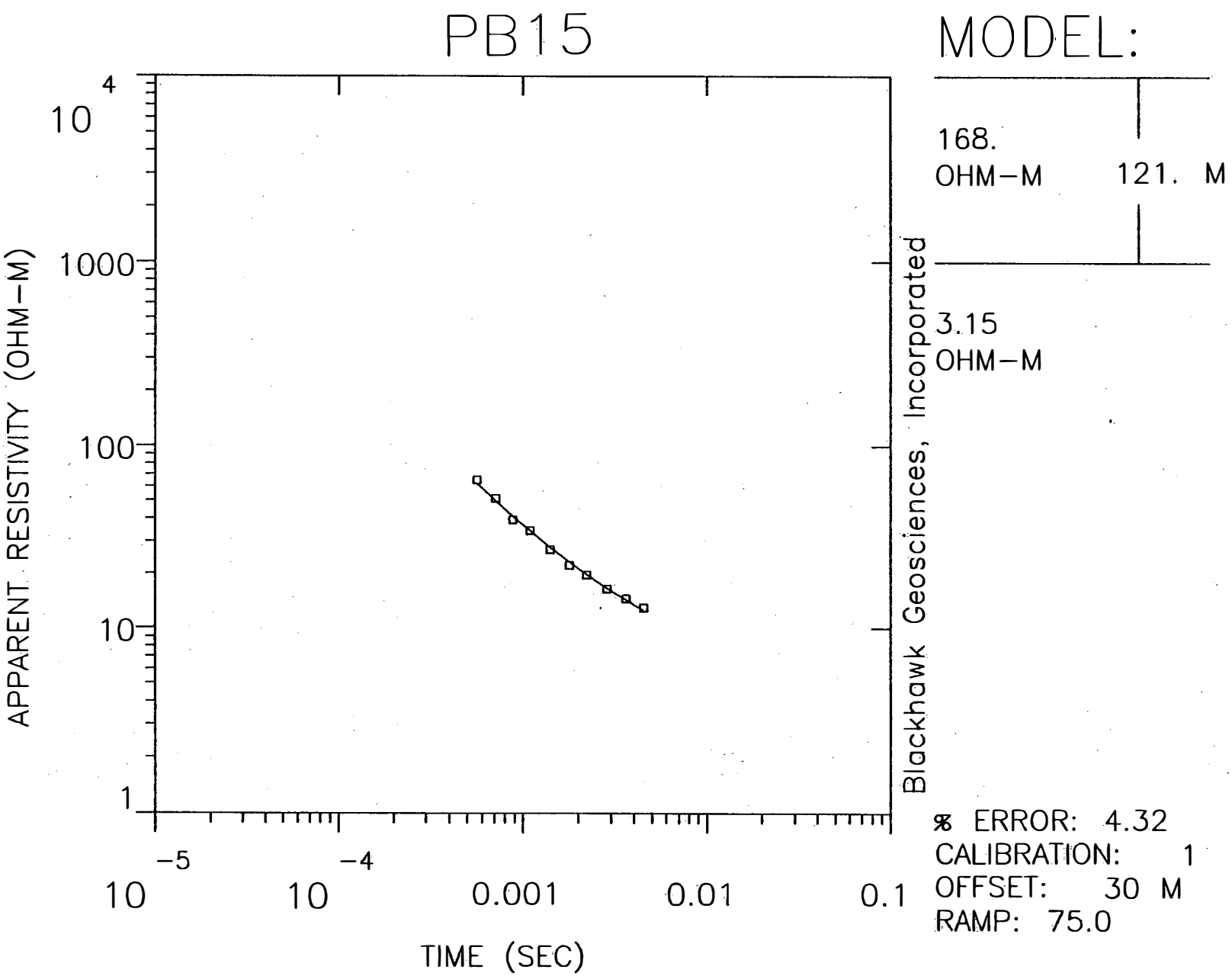
* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER
P 1 1.00
P 2 0.00 1.00
T 1 0.00 0.00 1.00

P 1 P 2 T 1

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	116.198	119.806	123.773
	2	15.328	17.567	20.312
THICK	1	313.491	329.774	342.895
DEPTH	1	313.491	329.774	342.895


PB15
MODEL:
168.
OHM-M
121. M
3.15
OHM-M
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
Blackhawk Geosciences, Incorporated
% ERROR: 4.32
CALIBRATION: 1
OFFSET: 30 M
RAMP: 75.0

PB15

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		109.7	360.0		
167.60	121.0	-11.3	-37.1	0.7	0.7
3.15					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	5.64E-04	6.51E+01	6.23E+01	4.540	
2	7.13E-04	5.14E+01	4.99E+01	3.021	
3	8.81E-04	3.94E+01	4.12E+01	-4.266	
4	1.10E-03	3.43E+01	3.42E+01	0.093	
5	1.41E-03	2.70E+01	2.77E+01	-2.712	
6	1.80E-03	2.23E+01	2.31E+01	-3.410	
7	2.22E-03	1.96E+01	1.97E+01	-0.533	
8	2.85E-03	1.65E+01	1.66E+01	-0.678	
9	3.60E-03	1.45E+01	1.43E+01	1.326	
10	4.49E-03	1.29E+01	1.25E+01	3.190	

R: 30. X: 0. Y: 30. DL: 60. REQ: 33. CF: 1.0000
CLHZ ARRAY, 10 DATA POINTS, RAMP: 75.0 MICROSEC, DATA: PB15
1108 PB 1500WZ OPR XTL H 4 8 +100
Ch.21 = 0.075 Ch.22 = 0.089 Ch.23 = 25 Ch.24 =
RMS LOG ERROR: 1.84E-02, ANTILOG YIELDS 4.3209 %
LATE TIME PARAMETERS

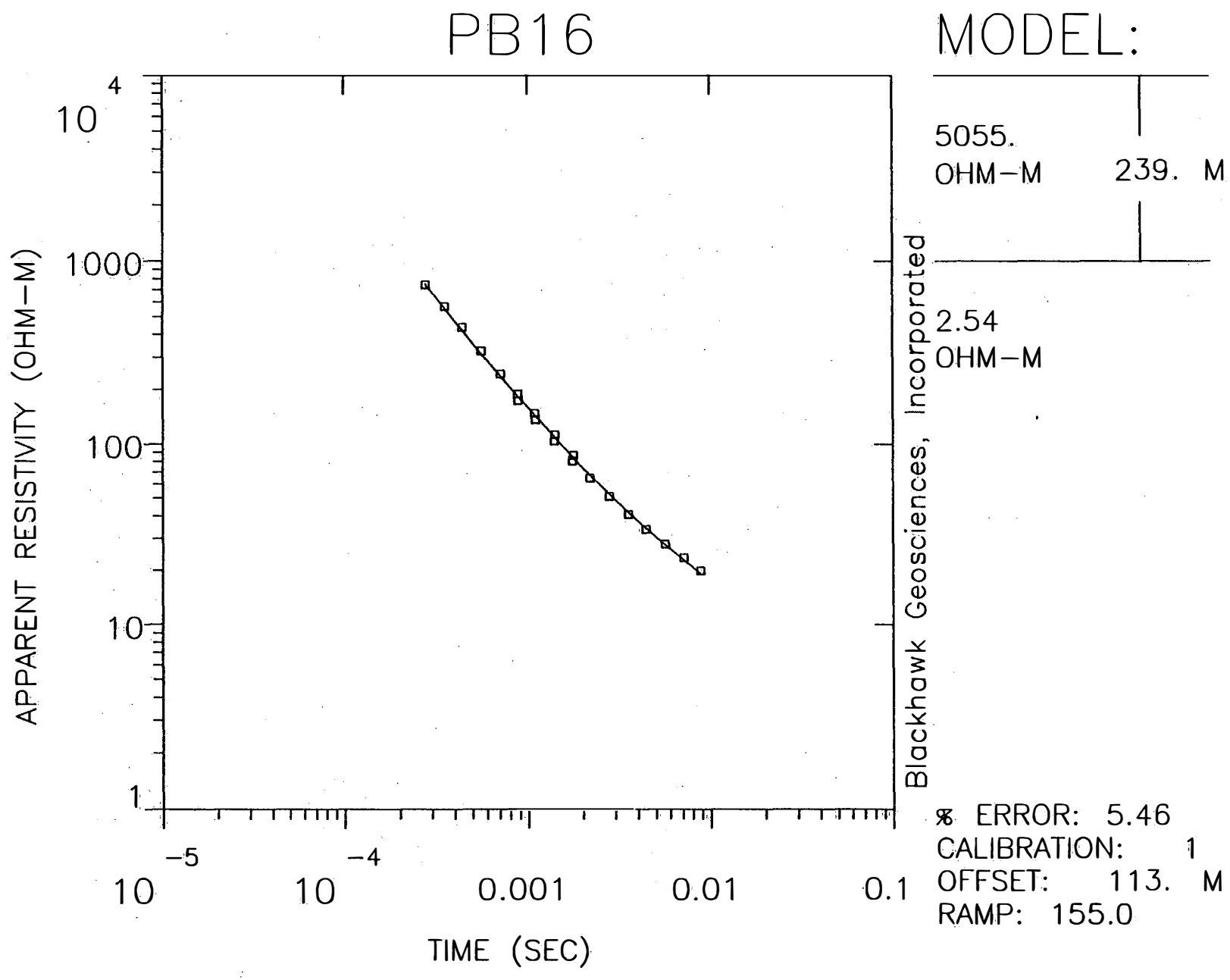
* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

	P 1	P 2	T 1
P 1	0.19		
P 2	-0.05	0.95	
T 1	0.03	0.01	1.00

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	97.320	167.602	590.948
	2	2.787	3.152	3.549
THICK	1	115.401	121.024	125.525
DEPTH	1	115.401	121.024	125.525


PB16
MODEL:
5055.
OHM-M
239. M
2.54
OHM-M
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
Blackhawk Geosciences, Incorporated
% ERROR: 5.46
CALIBRATION: 1
OFFSET: 113. M
RAMP: 155.0

PB16

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		214.0	702.0		
5054.61	239.4	-25.4	-83.4	0.0	0.0
2.54					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	2.80E-04	7.44E+02	7.53E+02	-1.226	
2	3.55E-04	5.71E+02	5.56E+02	2.622	
3	4.43E-04	4.38E+02	4.21E+02	3.980	
4	5.64E-04	3.24E+02	3.13E+02	3.597	
5	7.13E-04	2.44E+02	2.36E+02	3.377	
6	8.81E-04	1.89E+02	1.84E+02	2.704	
7	8.90E-04	1.74E+02	1.82E+02	-4.541	
8	1.10E-03	1.48E+02	1.44E+02	2.889	
9	1.10E-03	1.36E+02	1.43E+02	-4.984	
10	1.40E-03	1.04E+02	1.09E+02	-5.171	
11	1.41E-03	1.12E+02	1.08E+02	3.584	
12	1.77E-03	8.09E+01	8.47E+01	-4.586	
13	1.80E-03	8.68E+01	8.35E+01	3.935	
14	2.20E-03	6.47E+01	6.75E+01	-4.093	
15	2.80E-03	5.12E+01	5.29E+01	-3.071	
16	3.55E-03	4.08E+01	4.20E+01	-2.784	
17	4.43E-03	3.36E+01	3.42E+01	-1.616	
18	5.64E-03	2.79E+01	2.76E+01	0.930	
19	7.13E-03	2.34E+01	2.27E+01	3.369	
20	8.81E-03	1.99E+01	1.92E+01	3.793	

R: 113. X: 0. Y: 114. DL: 227. REQ: 127. CF: 1.0000
CLHZ ARRAY, 20 DATA POINTS, RAMP: 155.0 MICROSEC, DATA: PB16
1108 PB 1600WZ OPR XTL L 4 8 +100
Ch.21 = 0.14 Ch.22 = 0.89 Ch.23 = 18 Ch.24 = 51
RMS LOG ERROR: 2.31E-02, ANTILOG YIELDS 5.4573 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

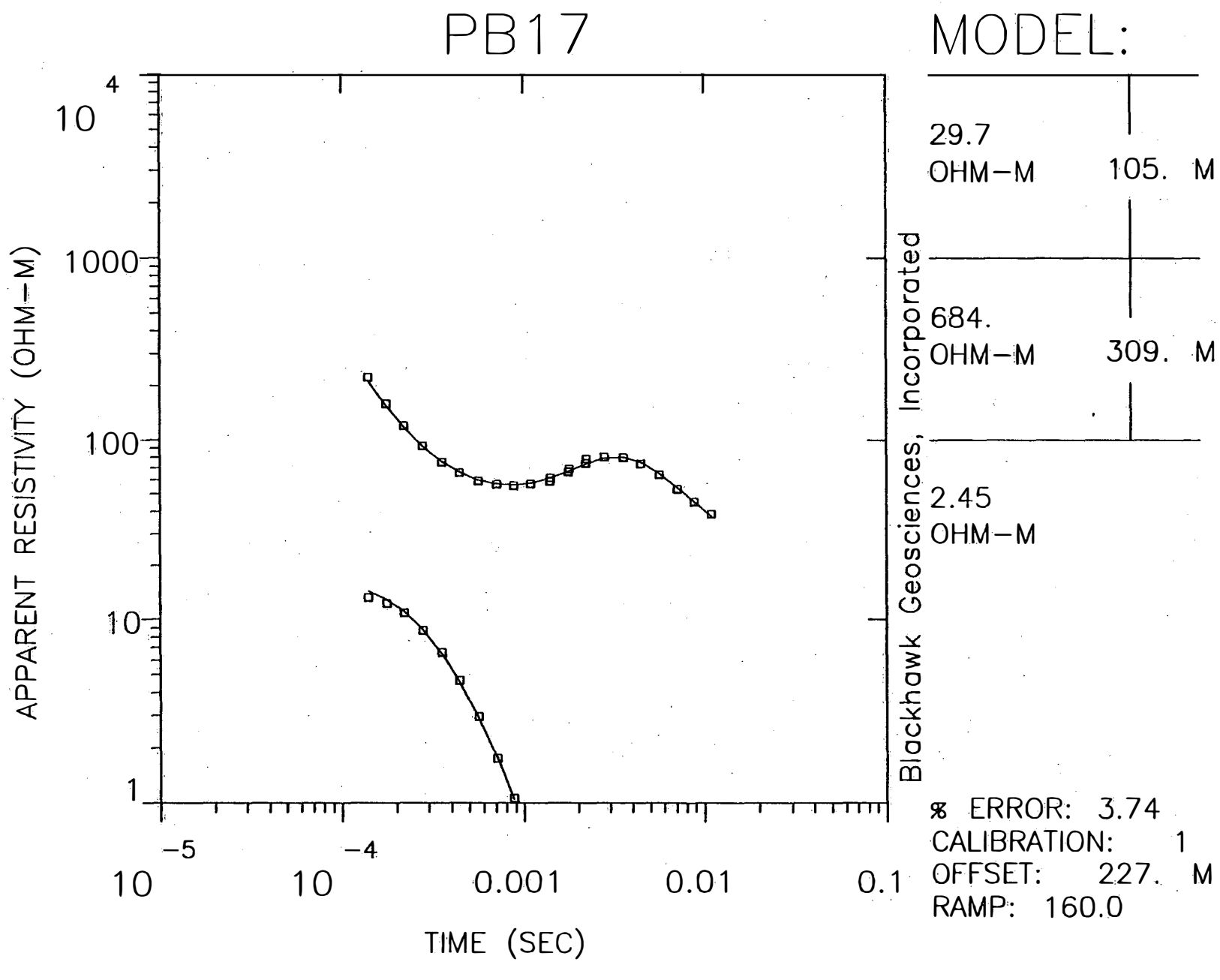
PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.08		
P 2	-0.02	1.00	
T 1	0.00	0.00	1.00
	P 1	P 2	T 1

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	577.017	5054.612	30105.744
	2	2.120	2.544	3.053

THICK	1	236.174	239.393	243.366
DEPTH	1	236.174	239.393	243.366


PB17
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
29.7
OHM-M
105. M
684.
OHM-M
309. M
2.45
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 3.74
CALIBRATION: 1
OFFSET: 227. M
RAMP: 160.0

PB17

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		351.1	1152.0		
29.71	105.0	246.1	807.5	3.5	3.5
684.20	309.0	-62.9	-206.3	0.5	4.0
2.45					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	1.40E-04	2.23E+02	2.11E+02	5.628	
2	1.77E-04	1.58E+02	1.53E+02	3.176	
3	2.20E-04	1.20E+02	1.18E+02	1.369	
4	2.80E-04	9.26E+01	9.21E+01	0.557	
5	3.55E-04	7.49E+01	7.57E+01	-1.052	
6	4.43E-04	6.54E+01	6.60E+01	-0.943	
7	5.64E-04	5.90E+01	5.97E+01	-1.016	
8	7.13E-04	5.65E+01	5.67E+01	-0.325	
9	8.81E-04	5.55E+01	5.61E+01	-1.063	
10	1.10E-03	5.69E+01	5.75E+01	-1.087	
11	1.40E-03	5.88E+01	6.14E+01	-4.242	
12	1.41E-03	6.13E+01	6.15E+01	-0.413	
13	1.77E-03	6.64E+01	6.70E+01	-1.023	
14	1.80E-03	6.89E+01	6.74E+01	2.136	
15	2.20E-03	7.42E+01	7.33E+01	1.231	
16	2.22E-03	7.84E+01	7.36E+01	6.546	
17	2.80E-03	8.03E+01	7.91E+01	1.484	
18	3.55E-03	7.98E+01	8.00E+01	-0.312	
19	4.43E-03	7.35E+01	7.50E+01	-1.914	
20	5.64E-03	6.39E+01	6.49E+01	-1.546	
21	7.13E-03	5.33E+01	5.40E+01	-1.306	
22	8.81E-03	4.49E+01	4.50E+01	-0.235	
23	1.10E-02	3.87E+01	3.72E+01	3.860	

R: 227. X: 0. Y: 228. DL: 455. REQ: 253. CF: 1.0000
CLHZ ARRAY, 23 DATA POINTS, RAMP: 160.0 MICROSEC, DATA: PB17
1108 PB 1700WZ OPR XTL L 4 8 +100
Ch.21 = 0.16 Ch.22 = 0.89 Ch.23 = 11 Ch.24 = 20
RMS LOG ERROR: 1.60E-02, ANTILOG YIELDS 3.7447 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

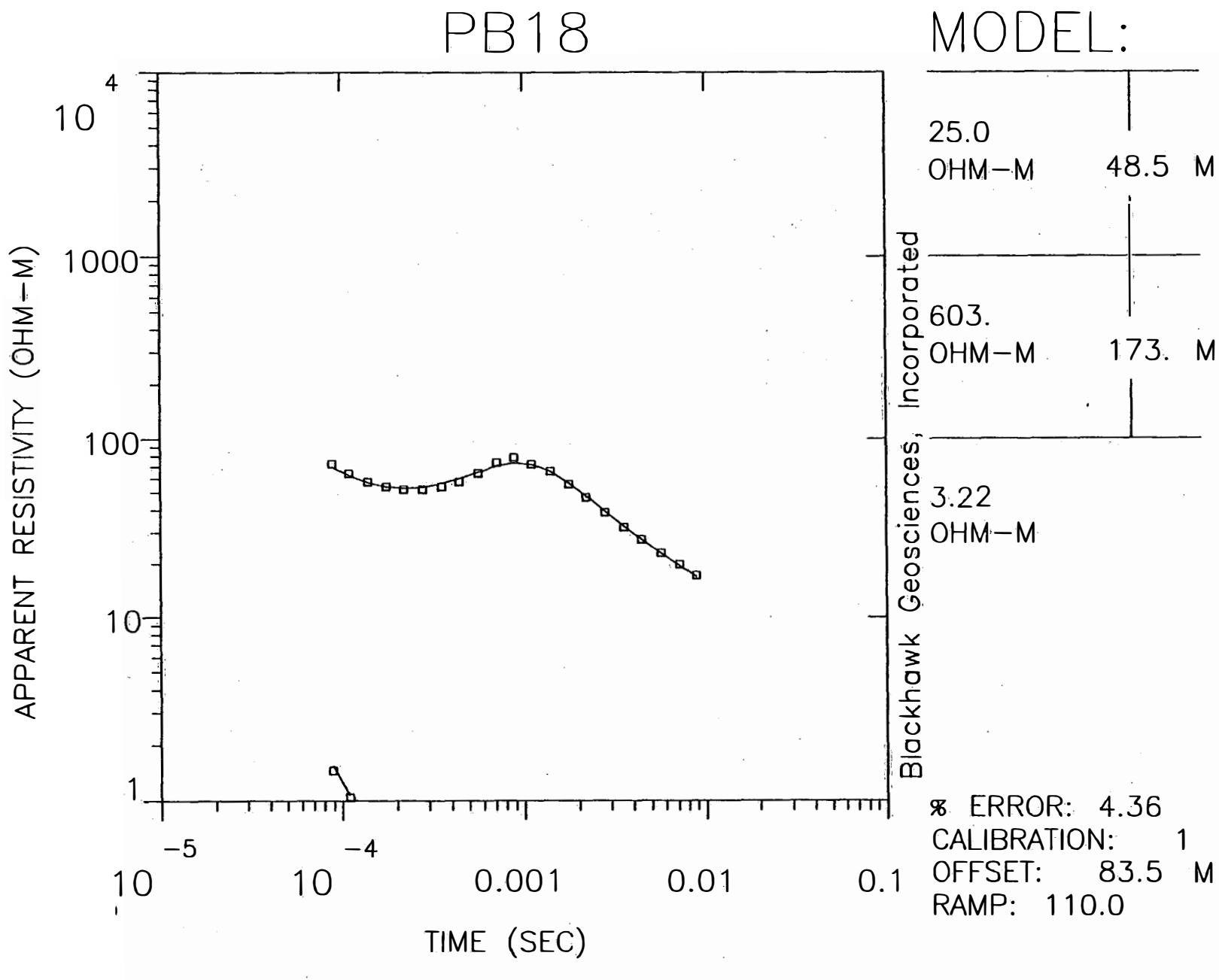
PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.99				
P 2	0.00	0.01			
P 3	0.02	-0.03	0.46		
T 1	-0.02	-0.04	0.05	0.97	
T 2	0.00	0.02	-0.03	0.01	0.99

P 1 P 2 P 3 T 1 T 2

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	27.438	29.705	31.859
	2	311.527	684.203	2731.000
	3	1.477	2.447	4.084
THICK	1	92.380	105.014	118.306
	2	287.371	308.994	325.033
DEPTH	1	92.380	105.014	118.306
	2	404.812	414.008	422.167


PB18
MODEL:
APPARENT RESISTIVITY (OHM-M)
10 4
1000
100
10
1
10 -5
10 -4
0.001
0.01
0.1
TIME (SEC)
25.0
OHM-M
48.5 M
603.
OHM-M
173. M
3.22
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 4.36
CALIBRATION: 1
OFFSET: 83.5 M
RAMP: 110.0

PB18

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		168.9	554.0		
25.01	48.5	120.4	394.9	1.9	1.9
603.06	173.1	-52.8	-173.1	0.3	2.2
3.22					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	7.27E+01	6.99E+01	4.038	
2	1.10E-04	6.39E+01	6.24E+01	2.355	
3	1.40E-04	5.77E+01	5.69E+01	1.471	
4	1.77E-04	5.41E+01	5.39E+01	0.311	
5	2.20E-04	5.22E+01	5.29E+01	-1.358	
6	2.80E-04	5.22E+01	5.37E+01	-2.700	
7	3.55E-04	5.37E+01	5.62E+01	-4.521	
8	4.43E-04	5.76E+01	6.00E+01	-3.995	
9	5.64E-04	6.42E+01	6.54E+01	-1.814	
10	7.13E-04	7.37E+01	7.06E+01	4.361	
11	8.81E-04	7.89E+01	7.32E+01	7.769	
12	1.10E-03	7.24E+01	7.19E+01	0.648	
13	1.40E-03	6.58E+01	6.55E+01	0.449	
14	1.77E-03	5.59E+01	5.65E+01	-1.021	
15	2.20E-03	4.69E+01	4.79E+01	-2.175	
16	2.80E-03	3.87E+01	3.95E+01	-1.927	
17	3.55E-03	3.20E+01	3.27E+01	-1.945	
18	4.43E-03	2.73E+01	2.75E+01	-0.527	
19	5.64E-03	2.30E+01	2.29E+01	0.450	
20	7.13E-03	1.99E+01	1.94E+01	2.234	
21	8.81E-03	1.71E+01	1.69E+01	1.513	

R: 83. X: 0. Y: 84. DL: 167. REQ: 93. CF: 1.0000
CLHZ ARRAY, 21 DATA POINTS, RAMP: 110.0 MICROSEC, DATA: PB18
1208 PB 1800WZ OPR XTL L 5 8 +100
Ch.21 = 0.11 Ch.22 = 0.89 Ch.23 = 18.5 Ch.24 =
RMS LOG ERROR: 1.85E-02, ANTILOG YIELDS 4.3606 %
LATE TIME PARAMETERS

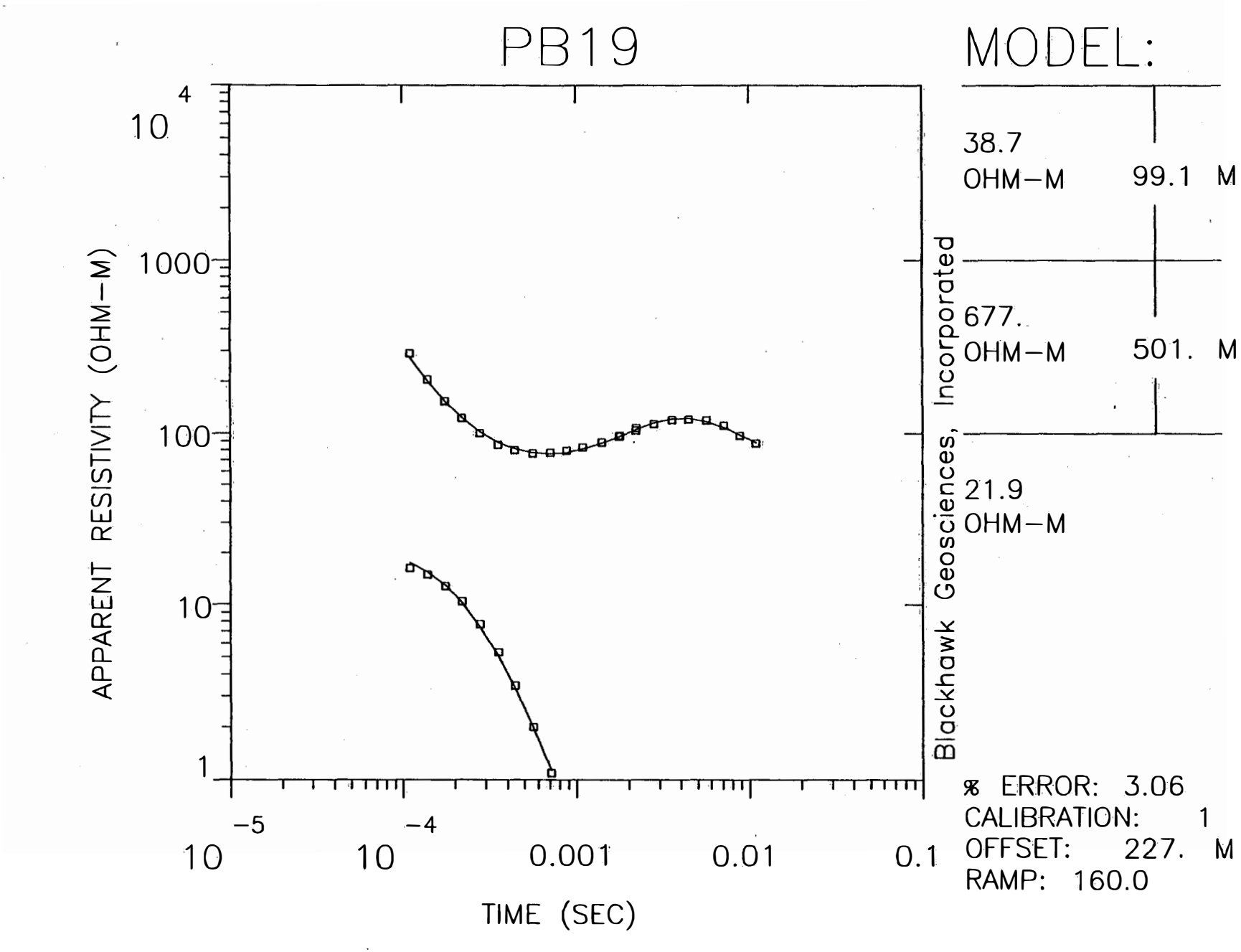
* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.98				
P 2	-0.01	0.01			
P 3	0.02	-0.01	0.87		
T 1	-0.03	-0.06	0.03	0.95	
T 2	0.00	0.02	0.00	0.01	1.00
	P 1	P 2	P 3	T 1	T 2

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	22.835	25.014	27.950
	2	274.582	603.062	2572.424
	3	2.501	3.217	3.937
THICK	1	42.078	48.487	57.824
	2	162.783	173.130	181.045
DEPTH	1	42.078	48.487	57.824
	2	218.256	221.618	226.028


PB19
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
38.7
OHM-M
99.1 M
677.
OHM-M
501. M
21.9
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 3.06
CALIBRATION: 1
OFFSET: 227. M
RAMP: 160.0

PB19

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		399.0	1309.0		
38.65	99.1	299.9	983.8	2.6	2.6
677.27	500.7	-200.8	-658.8	0.7	3.3
21.92					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	1.10E-04	2.89E+02	2.75E+02	4.992	
2	1.40E-04	2.05E+02	2.01E+02	2.294	
3	1.77E-04	1.54E+02	1.53E+02	0.620	
4	2.20E-04	1.22E+02	1.24E+02	-0.930	
5	2.80E-04	9.99E+01	1.02E+02	-2.227	
6	3.55E-04	8.60E+01	8.89E+01	-3.232	
7	4.43E-04	7.96E+01	8.13E+01	-2.072	
8	5.64E-04	7.66E+01	7.70E+01	-0.521	
9	7.13E-04	7.75E+01	7.59E+01	2.137	
10	8.81E-04	7.91E+01	7.72E+01	2.417	
11	1.10E-03	8.27E+01	8.07E+01	2.356	
12	1.41E-03	8.86E+01	8.75E+01	1.289	
13	1.77E-03	9.56E+01	9.57E+01	-0.022	
14	1.80E-03	9.68E+01	9.62E+01	0.553	
15	2.20E-03	1.04E+02	1.05E+02	-0.887	
16	2.22E-03	1.07E+02	1.05E+02	1.328	
17	2.80E-03	1.13E+02	1.15E+02	-1.215	
18	3.55E-03	1.20E+02	1.21E+02	-1.517	
19	4.43E-03	1.20E+02	1.22E+02	-1.578	
20	5.64E-03	1.19E+02	1.17E+02	1.548	
21	7.13E-03	1.11E+02	1.08E+02	3.099	
22	8.81E-03	9.68E+01	9.81E+01	-1.382	
23	1.10E-02	8.71E+01	8.84E+01	-1.408	

R: 227. X: 0. Y: 228. DL: 455. REQ: 253. CF: 1.0000
CLHZ ARRAY, 23 DATA POINTS, RAMP: 160.0 MICROSEC, DATA: PB19
1208 PB 1900WZ OPR XTL L 6 8 +100
Ch.21 = 0.16 Ch.22 = 0.89 Ch.23 = 11 Ch.24 = 20
RMS LOG ERROR: 1.31E-02, ANTILOG YIELDS 3.0574 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

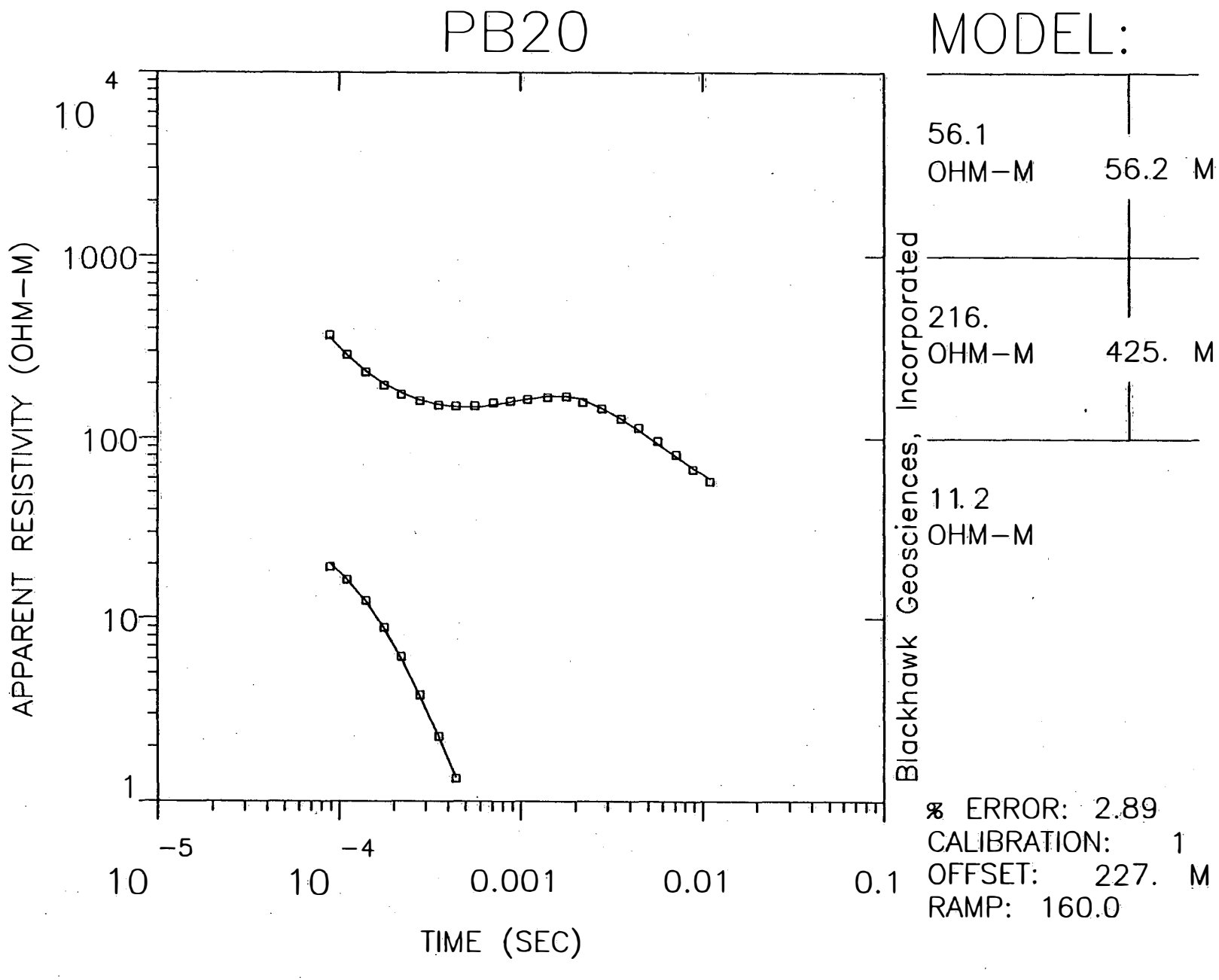
PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	1.00				
P 2	0.00	0.82			
P 3	0.00	-0.04	0.97		
T 1	0.00	-0.02	0.00	1.00	
T 2	0.00	0.02	0.01	0.00	1.00

P 1 P 2 P 3 T 1 T 2

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	36.757	38.653	40.201
	2	373.248	677.273	1092.274
	3	14.793	21.915	28.907
THICK	1	88.036	99.118	108.731
	2	472.653	500.681	543.345
DEPTH	1	88.036	99.118	108.731
	2	575.114	599.799	637.903


PB20
MODEL:
APPARENT RESISTIVITY (OHM-M)
10 4
1000
100
10
1
10 -5
10 -4
0.001
0.01
0.1
TIME (SEC)
56.1
OHM-M
56.2 M
216.
OHM-M
425. M
11.2
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 2.89
CALIBRATION: 1
OFFSET: 227. M
RAMP: 160.0

PB20

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		377.0	1237.0		
56.08	56.2	320.9	1052.8	1.0	1.0
216.09	425.2	-104.4	-342.4	2.0	3.0
11.18					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	3.68E+02	3.58E+02	2.778	
2	1.10E-04	2.88E+02	2.87E+02	0.351	
3	1.40E-04	2.31E+02	2.33E+02	-0.973	
4	1.77E-04	1.96E+02	1.99E+02	-1.487	
5	2.20E-04	1.74E+02	1.77E+02	-1.812	
6	2.80E-04	1.60E+02	1.62E+02	-0.785	
7	3.55E-04	1.52E+02	1.53E+02	-0.560	
8	4.43E-04	1.50E+02	1.49E+02	0.865	
9	5.64E-04	1.51E+02	1.49E+02	1.635	
10	7.13E-04	1.57E+02	1.52E+02	2.788	
11	8.81E-04	1.60E+02	1.58E+02	1.262	
12	1.10E-03	1.64E+02	1.64E+02	-0.249	
13	1.41E-03	1.68E+02	1.70E+02	-1.493	
14	1.80E-03	1.69E+02	1.70E+02	-0.362	
15	2.20E-03	1.57E+02	1.63E+02	-3.203	
16	2.80E-03	1.45E+02	1.47E+02	-1.451	
17	3.55E-03	1.28E+02	1.28E+02	-0.314	
18	4.43E-03	1.14E+02	1.11E+02	2.833	
19	5.64E-03	9.63E+01	9.33E+01	3.170	
20	7.13E-03	8.11E+01	7.92E+01	2.429	
21	8.81E-03	6.72E+01	6.85E+01	-1.954	
22	1.10E-02	5.77E+01	5.94E+01	-2.987	

R: 227. X: 0. Y: 228. DL: 455. REQ: 253. CF: 1.0000
CLHZ ARRAY, 22 DATA POINTS, RAMP: 160.0 MICROSEC, DATA: PB20
1208 PB 2000NZ OPR XTL L 6 8 +100
Ch.21 = 0.16 Ch.22 = 0.89 Ch.23 = 11 Ch.24 = 20
RMS LOG ERROR: 1.24E-02, ANTILOG YIELDS 2.8887 %
LATE TIME PARAMETERS

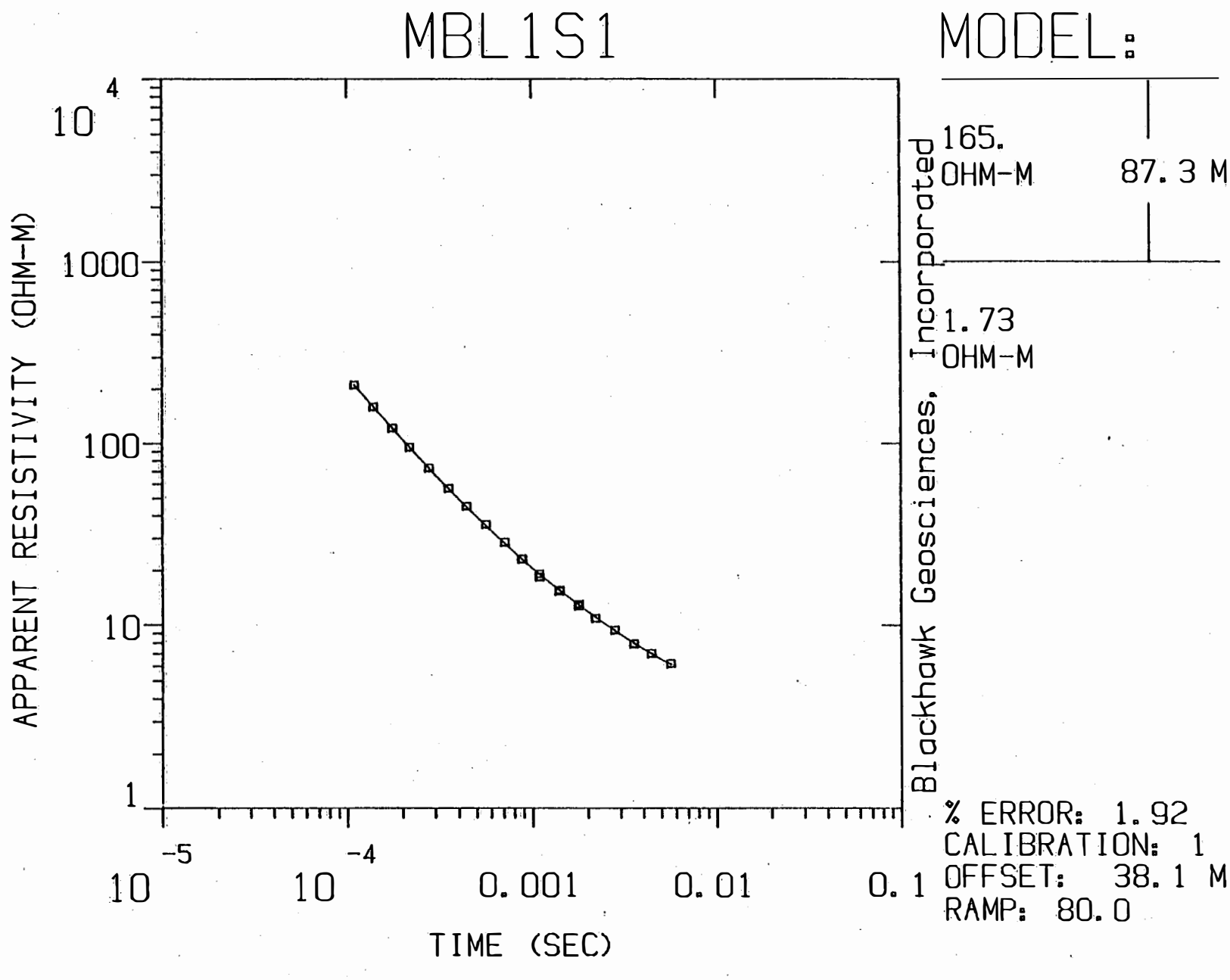
* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	1.00				
P 2	0.00	1.00			
P 3	0.00	0.00	1.00		
T 1	0.00	-0.01	0.00	0.99	
T 2	0.00	0.00	0.00	0.00	1.00
	P 1	P 2	P 3	T 1	T 2

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	49.381	56.082	65.099
	2	188.077	216.090	265.098
	3	9.075	11.175	13.930
THICK	1	42.234	56.158	79.231
	2	396.115	425.236	446.708
DEPTH	1	42.234	56.158	79.231
	2	471.959	481.394	492.100


MBL1S1
MODEL:
APPARENT RESISTIVITY (OHM-M)
10 4
1000
100
10
1
10 -5
10 -4
0.001
0.01
0.1
TIME (SEC)
165.
OHM-M
87.3 M
1.73
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 1.92
CALIBRATION: 1
OFFSET: 38.1 M
RAMP: 80.0

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		75.0	246.0		
165.43	87.3	-12.4	-40.5	0.5	0.5
1.73					

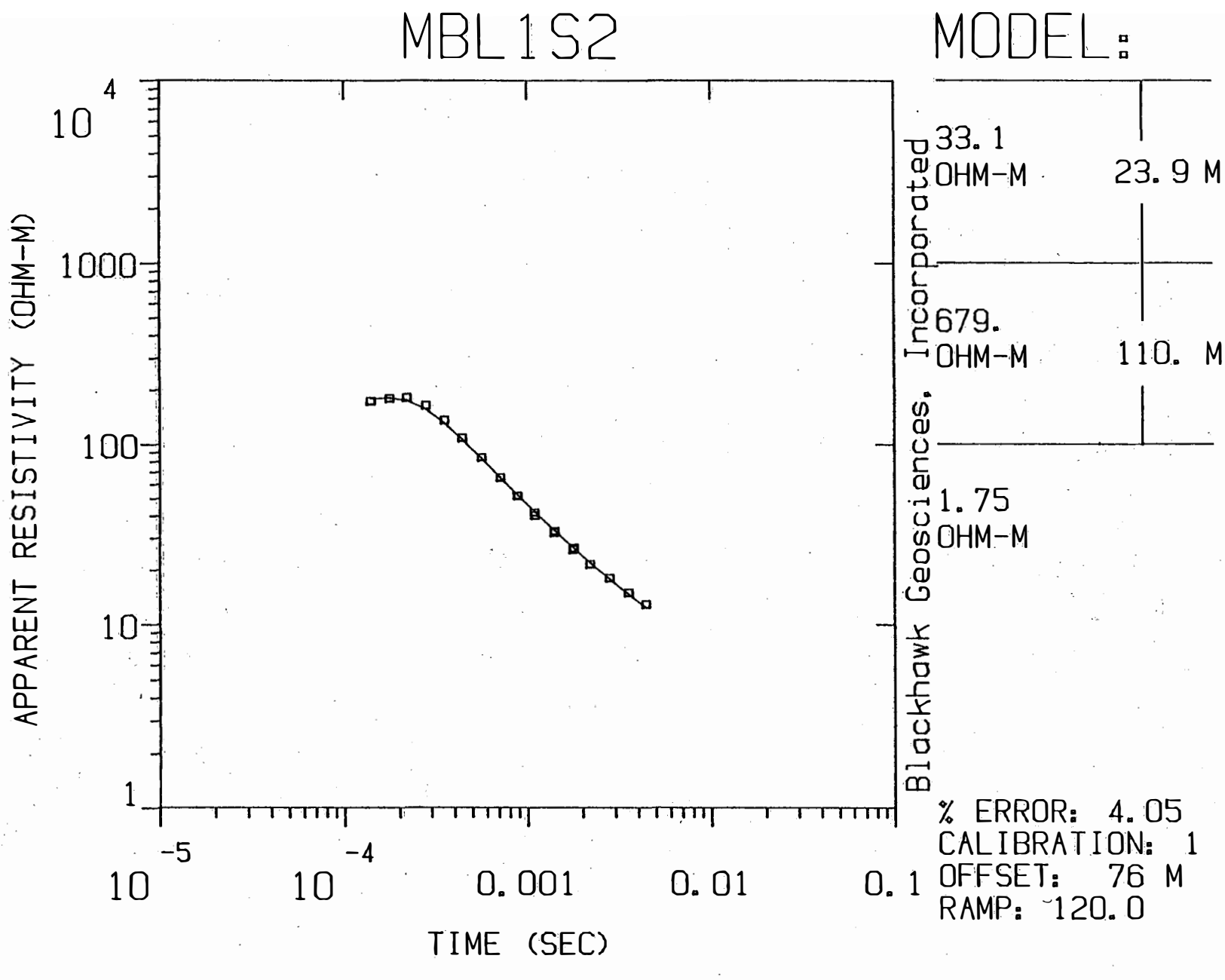
	TIMES	DATA	CALC	% ERROR	STD ERR
1	1.10E-04	2.10E+02	2.10E+02	-0.237	
2	1.40E-04	1.59E+02	1.59E+02	0.033	
3	1.77E-04	1.21E+02	1.21E+02	-0.221	
4	2.20E-04	9.48E+01	9.48E+01	-0.014	
5	2.80E-04	7.28E+01	7.26E+01	0.202	
6	3.55E-04	5.65E+01	5.63E+01	0.230	
7	4.43E-04	4.50E+01	4.48E+01	0.622	
8	5.64E-04	3.57E+01	3.51E+01	1.606	
9	7.13E-04	2.84E+01	2.80E+01	1.291	
10	8.81E-04	2.31E+01	2.31E+01	0.063	
11	8.90E-04	2.30E+01	2.29E+01	0.576	
12	1.10E-03	1.91E+01	1.90E+01	0.106	
13	1.10E-03	1.83E+01	1.90E+01	-3.556	
14	1.40E-03	1.53E+01	1.55E+01	-1.657	
15	1.41E-03	1.55E+01	1.54E+01	0.693	
16	1.77E-03	1.26E+01	1.29E+01	-2.024	
17	1.80E-03	1.30E+01	1.28E+01	1.770	
18	2.20E-03	1.08E+01	1.10E+01	-1.472	
19	2.80E-03	9.34E+00	9.27E+00	0.747	
20	3.55E-03	7.88E+00	7.95E+00	-0.846	
21	4.43E-03	7.00E+00	6.96E+00	0.620	
22	5.64E-03	6.18E+00	6.08E+00	1.639	

R: 38. X: 0. Y: 38. DL: 76. REQ: 42. CF: 1.0000
CLHZ ARRAY, 22 DATA POINTS, RAMP: 80.0 MICROSEC, DATA: MBL1S1
0502 100 1NZ OPR L 5 8 -
Ch.21 = 0.08 Ch.22 = 0.89 Ch.23 = 19.5 Ch.24 =
RMS LOG ERROR: 8.25E-03, ANTILOG YIELDS 1.9168 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.23		
P 2	-0.08	0.96	
T 1	0.03	0.00	1.00
	P 1	P 2	T 1


MBL1S2
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
33.1
OHM-M
23.9 M
679.
OHM-M
110. M
1.75
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 4.05
CALIBRATION: 1
OFFSET: 76 M
RAMP: 120.0

MBL1S2

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		120.1	394.0		
33.08	23.9	96.2	315.5	0.7	0.7
678.91	110.2	-14.0	-46.0	0.2	0.9
1.75					

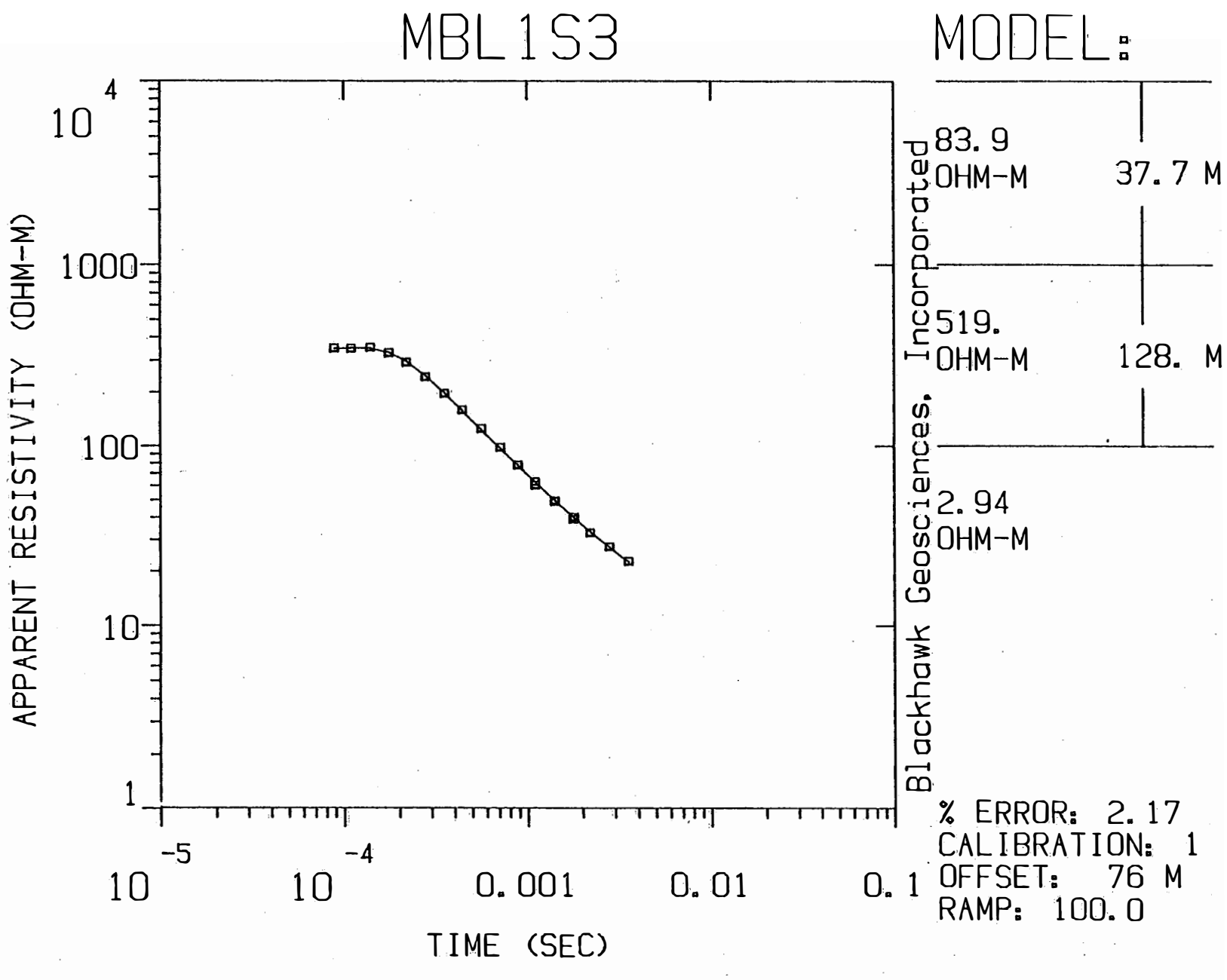
	TIMES	DATA	CALC	% ERROR	STD ERR
1	1.40E-04	1.73E+02	1.80E+02	-3.917	
2	1.77E-04	1.79E+02	1.81E+02	-1.087	
3	2.20E-04	1.81E+02	1.75E+02	3.366	
4	2.80E-04	1.64E+02	1.57E+02	4.697	
5	3.55E-04	1.36E+02	1.31E+02	3.761	
6	4.43E-04	1.08E+02	1.06E+02	1.586	
7	5.64E-04	8.41E+01	8.33E+01	0.970	
8	7.13E-04	6.53E+01	6.53E+01	-0.037	
9	8.81E-04	5.18E+01	5.26E+01	-1.359	
10	8.90E-04	5.18E+01	5.20E+01	-0.419	
11	1.10E-03	4.16E+01	4.22E+01	-1.396	
12	1.10E-03	4.02E+01	4.20E+01	-4.457	
13	1.40E-03	3.22E+01	3.32E+01	-3.245	
14	1.41E-03	3.28E+01	3.30E+01	-0.615	
15	1.77E-03	2.59E+01	2.67E+01	-3.037	
16	1.80E-03	2.65E+01	2.63E+01	0.511	
17	2.20E-03	2.15E+01	2.19E+01	-1.804	
18	2.80E-03	1.80E+01	1.78E+01	1.230	
19	3.55E-03	1.49E+01	1.47E+01	1.903	
20	4.43E-03	1.29E+01	1.24E+01	4.554	

R: 76. X: 0. Y: 76. DL: 152. REQ: 84. CF: 1.0000
CLHZ ARRAY, 20 DATA POINTS, RAMP: 120.0 MICROSEC, DATA: MBL1S2
0502 100 2NZ OPR L 5 8 -
Ch.21 = 0.12 Ch.22 = 0.89 Ch.23 = 19 Ch.24 = 23
RMS LOG ERROR: 1.73E-02, ANTILOG YIELDS 4.0524 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.52				
P 2	0.03	0.00			
P 3	-0.03	-0.01	0.18		
T 1	-0.43	-0.03	0.06	0.41	
T 2	0.10	0.01	0.00	0.11	0.95
	P 1	P 2	P 3	T 1	T 2


MBL1S3
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
83.9
OHM-M
37.7 M
519.
OHM-M
128. M
2.94
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 2.17
CALIBRATION: 1
OFFSET: 76 M
RAMP: 100.0

MBL1S3

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		154.8	508.0		
83.87	37.7	117.2	384.4	0.4	0.4
518.60	128.1	-10.9	-35.8	0.2	0.7
2.94					

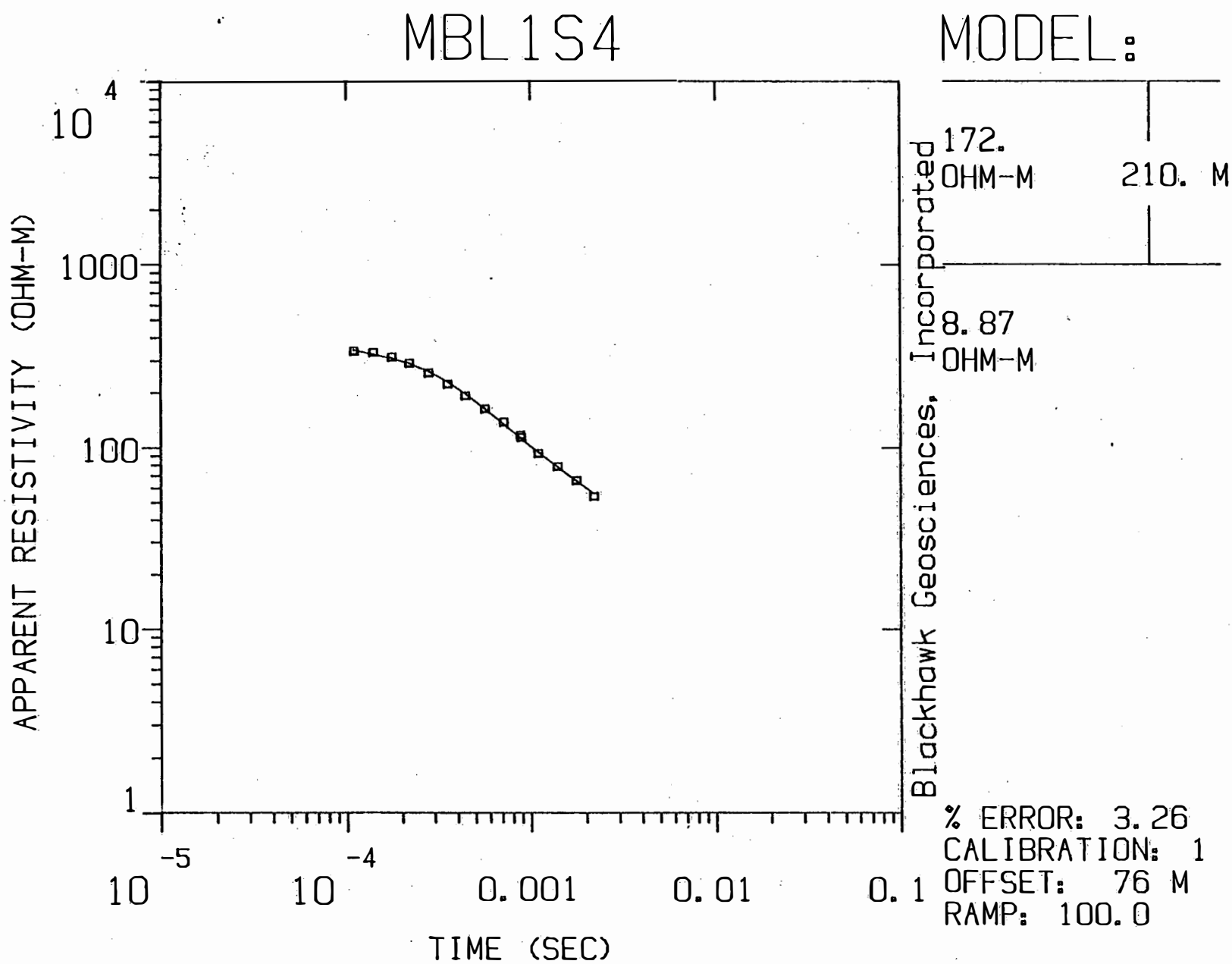
	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	3.46E+02	3.46E+02	0.101	
2	1.10E-04	3.45E+02	3.48E+02	-0.767	
3	1.40E-04	3.50E+02	3.46E+02	1.312	
4	1.77E-04	3.27E+02	3.28E+02	-0.313	
5	2.20E-04	2.91E+02	2.95E+02	-1.261	
6	2.80E-04	2.42E+02	2.46E+02	-1.460	
7	3.55E-04	1.96E+02	1.97E+02	-0.381	
8	4.43E-04	1.59E+02	1.57E+02	0.891	
9	5.64E-04	1.25E+02	1.22E+02	2.067	
10	7.13E-04	9.77E+01	9.61E+01	1.679	
11	8.81E-04	7.78E+01	7.76E+01	0.295	
12	8.90E-04	7.78E+01	7.68E+01	1.299	
13	1.10E-03	6.27E+01	6.26E+01	0.188	
14	1.10E-03	6.01E+01	6.23E+01	-3.560	
15	1.40E-03	4.89E+01	4.95E+01	-1.309	
16	1.41E-03	4.94E+01	4.92E+01	0.476	
17	1.77E-03	3.89E+01	4.00E+01	-2.642	
18	1.80E-03	4.00E+01	3.95E+01	1.299	
19	2.20E-03	3.27E+01	3.30E+01	-1.067	
20	2.80E-03	2.73E+01	2.70E+01	0.988	
21	3.55E-03	2.26E+01	2.24E+01	1.122	

R: 76. X: 0. Y: 76. DL: 152. REQ: 84. CF: 1.0000
CLHZ ARRAY, 21 DATA POINTS, RAMP: 100.0 MICROSEC, DATA: MBL1S3
0602 100N 3NZ OPR L 5 8 -TXP=3 1
Ch.21 = 0.1 Ch.22 = 0.89 Ch.23 = 15.5 Ch.24 = 2
RMS LOG ERROR: 9.34E-03, ANTILOG YIELDS 2.1734 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.78				
P 2	0.04	0.05			
P 3	0.04	-0.04	0.90		
T 1	-0.29	-0.15	0.07	0.57	
T 2	0.08	0.05	-0.02	0.12	0.97
	P 1	P 2	P 3	T 1	T 2


MBL1S4
MODEL:
APPARENT RESISTIVITY (OHM-M)
10 4
1000
100
10
1
10 -5
10 -4
0.001
0.01
0.1
TIME (SEC)
172.
OHM-M
210. M
8.87
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 3.26
CALIBRATION: 1
OFFSET: 76 M
RAMP: 100.0

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		219.5	720.0		
171.55	210.3	9.1	29.9	1.2	1.2
8.87					

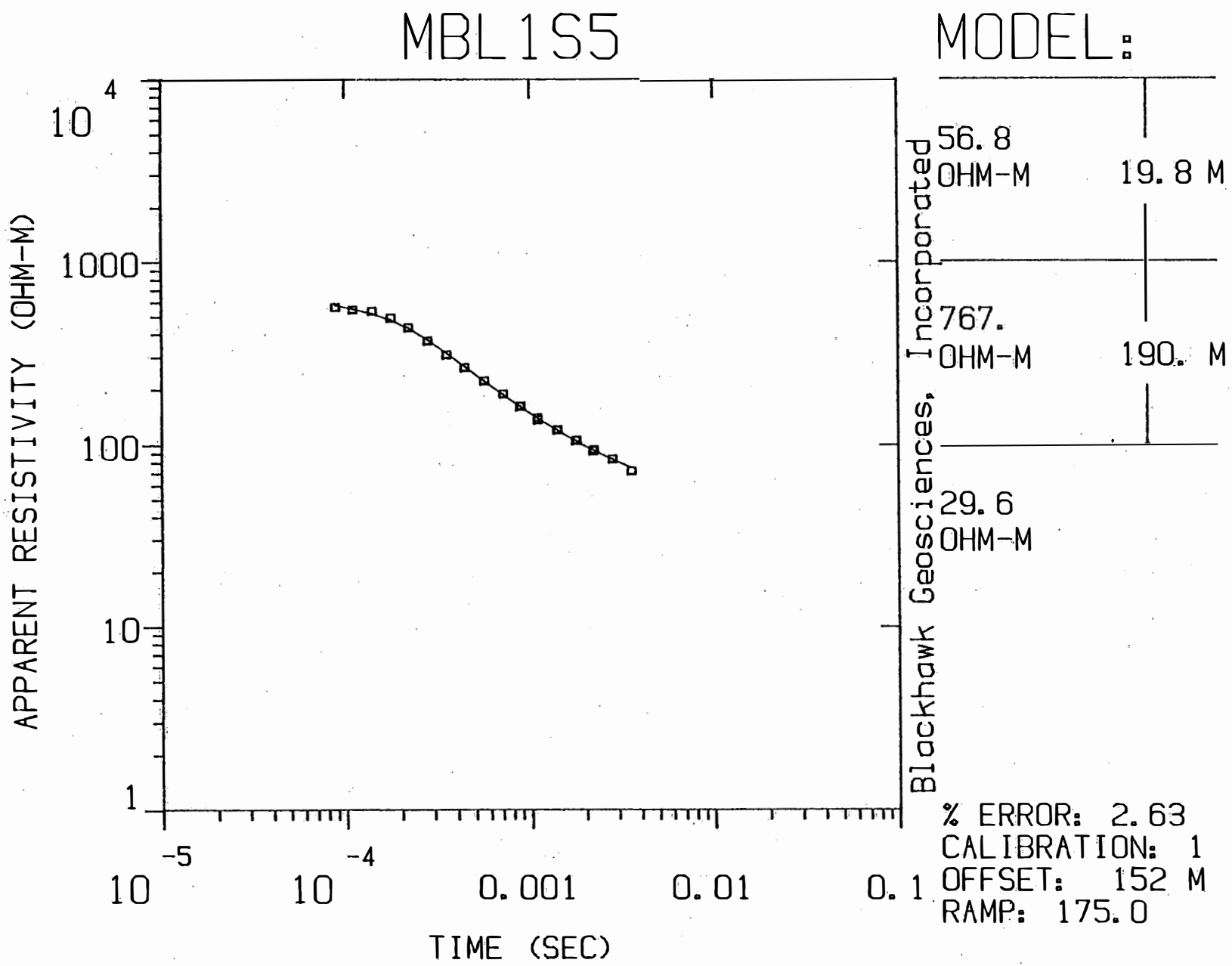
	TIMES	DATA	CALC	% ERROR	STD ERR
1	1.10E-04	3.37E+02	3.43E+02	-1.533	
2	1.40E-04	3.32E+02	3.24E+02	2.413	
3	1.77E-04	3.13E+02	3.08E+02	1.754	
4	2.20E-04	2.91E+02	2.90E+02	0.374	
5	2.80E-04	2.57E+02	2.63E+02	-2.211	
6	3.55E-04	2.23E+02	2.30E+02	-2.918	
7	4.43E-04	1.92E+02	1.97E+02	-2.320	
8	5.64E-04	1.63E+02	1.63E+02	-0.021	
9	7.13E-04	1.38E+02	1.34E+02	2.553	
10	8.81E-04	1.17E+02	1.13E+02	3.892	
11	8.90E-04	1.14E+02	1.12E+02	1.586	
12	1.10E-03	9.26E+01	9.42E+01	-1.612	
13	1.40E-03	7.83E+01	7.79E+01	0.523	
14	1.77E-03	6.57E+01	6.52E+01	0.680	
15	2.20E-03	5.40E+01	5.58E+01	-3.295	

R: 76. X: 0. Y: 76. DL: 152. REQ: 84. CF: 1.0000
CLHZ ARRAY, 15 DATA POINTS, RAMP: 100.0 MICROSEC, DATA: MBL1S4
0602 100N 4NZ OPR L 6 8 -TXP=4
Ch.21 = 0.1 Ch.22 = 0.89 Ch.23 = 15.5 Ch.24 = 2
RMS LOG ERROR: 1.39E-02, ANTILOG YIELDS 3.2579 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

	P 1	P 2	T 1
P 1	1.00		
P 2	0.00	1.00	
T 1	0.00	0.00	1.00


MBL1S5
MODEL:
APPARENT RESISTIVITY (OHM-M)
10 4
1000
100
10
1
10 -5
10 -4
0.001
0.01
0.1
TIME (SEC)
56.8
OHM-M
19.8 M
767.
OHM-M
190. M
29.6
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 2.63
CALIBRATION: 1
OFFSET: 152 M
RAMP: 175.0

MBL1SS

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		270.1	886.0		
56.75	19.8	250.2	821.0	0.3	0.3
767.35	190.1	60.1	197.2	0.2	0.6
29.63					

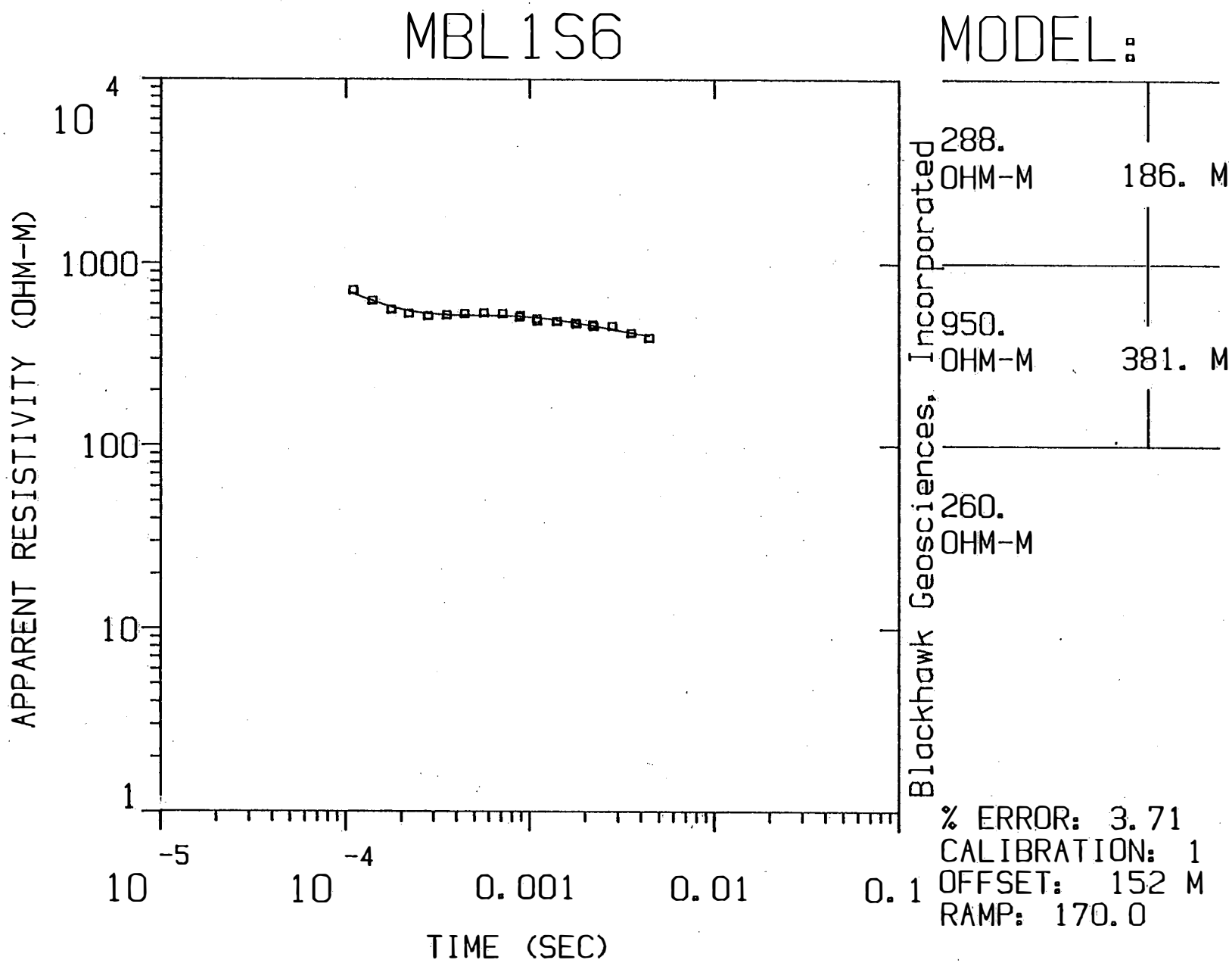
	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	5.66E+02	5.78E+02	-2.127	
2	1.10E-04	5.47E+02	5.51E+02	-0.732	
3	1.40E-04	5.37E+02	5.18E+02	3.591	
4	1.77E-04	4.91E+02	4.78E+02	2.765	
5	2.20E-04	4.35E+02	4.31E+02	0.965	
6	2.80E-04	3.67E+02	3.72E+02	-1.306	
7	3.55E-04	3.09E+02	3.15E+02	-1.914	
8	4.43E-04	2.63E+02	2.67E+02	-1.400	
9	5.64E-04	2.22E+02	2.22E+02	0.091	
10	7.13E-04	1.89E+02	1.87E+02	0.814	
11	8.81E-04	1.61E+02	1.61E+02	-0.025	
12	8.90E-04	1.63E+02	1.60E+02	1.663	
13	1.10E-03	1.40E+02	1.40E+02	0.647	
14	1.10E-03	1.37E+02	1.39E+02	-1.817	
15	1.40E-03	1.20E+02	1.20E+02	0.362	
16	1.41E-03	1.21E+02	1.19E+02	1.248	
17	1.77E-03	1.05E+02	1.05E+02	0.518	
18	1.80E-03	1.06E+02	1.04E+02	1.904	
19	2.20E-03	9.26E+01	9.33E+01	-0.727	
20	2.22E-03	9.43E+01	9.28E+01	1.620	
21	2.80E-03	8.37E+01	8.30E+01	0.903	
22	3.55E-03	7.18E+01	7.47E+01	-3.925	

R: 152. X: 0. Y: 152. DL: 304. REQ: 169. CF: 1.0000
CLHZ ARRAY, 22 DATA POINTS, RAMP: 175.0 MICROSEC, DATA: MBL1SS
0207 100N 5NZ OPR L 6 8 -LIN=100N 2
Ch.21 = 0.175 Ch.22 = 0.89 Ch.23 = 15 Ch.24 = 9
RMS LOG ERROR: 1.13E-02, ANTILOG YIELDS 2.6328 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.66				
P 2	0.02	0.13			
P 3	0.03	-0.04	0.97		
T 1	-0.37	-0.20	0.03	0.53	
T 2	0.03	0.06	0.01	0.05	0.99
	P 1	P 2	P 3	T 1	T 2


MBL1S6
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
288.
OHM-M
186. M
950.
OHM-M
381. M
260.
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 3.71
CALIBRATION: 1
OFFSET: 152 M
RAMP: 170.0

MBL1S6

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		365.2	1198.0		
288.15	186.4	178.8	586.6	0.6	0.6
949.63	381.0	-202.2	-663.3	0.4	1.0
259.96					

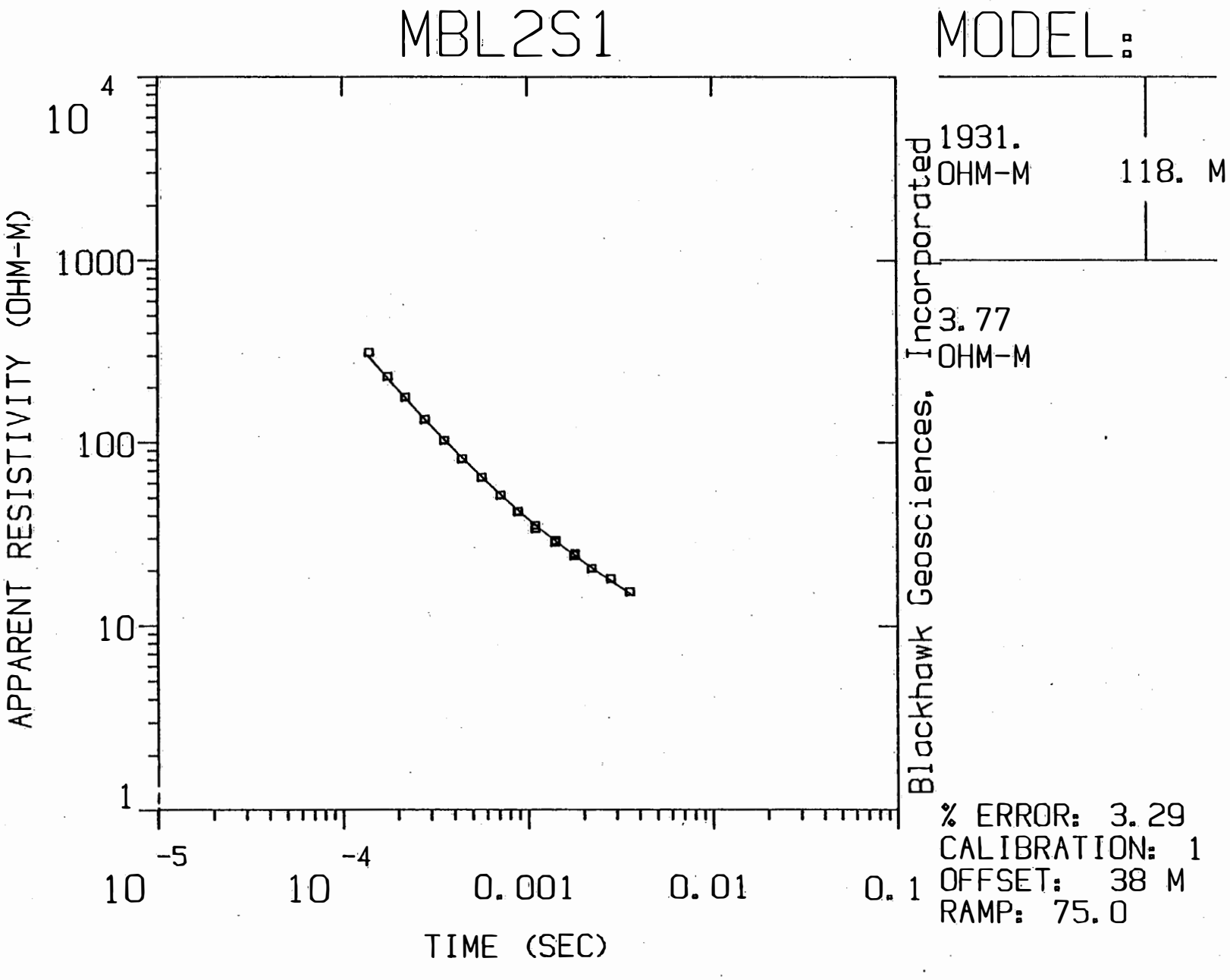
	TIMES	DATA	CALC	% ERROR	STD ERR
1	1.10E-04	7.15E+02	6.85E+02	4.483	
2	1.40E-04	6.27E+02	6.21E+02	0.820	
3	1.77E-04	5.60E+02	5.78E+02	-3.025	
4	2.20E-04	5.34E+02	5.50E+02	-2.950	
5	2.80E-04	5.17E+02	5.31E+02	-2.556	
6	3.55E-04	5.23E+02	5.21E+02	0.430	
7	4.43E-04	5.32E+02	5.18E+02	2.762	
8	5.64E-04	5.37E+02	5.17E+02	3.917	
9	7.13E-04	5.33E+02	5.16E+02	3.373	
10	8.81E-04	5.10E+02	5.12E+02	-0.410	
11	8.90E-04	5.20E+02	5.12E+02	1.647	
12	1.10E-03	4.99E+02	5.04E+02	-1.071	
13	1.10E-03	4.85E+02	5.04E+02	-3.845	
14	1.40E-03	4.84E+02	4.91E+02	-1.372	
15	1.41E-03	4.83E+02	4.90E+02	-1.378	
16	1.77E-03	4.75E+02	4.74E+02	0.305	
17	1.80E-03	4.68E+02	4.73E+02	-0.987	
18	2.20E-03	4.64E+02	4.56E+02	1.616	
19	2.22E-03	4.55E+02	4.55E+02	-0.173	
20	2.80E-03	4.56E+02	4.36E+02	4.524	
21	3.55E-03	4.17E+02	4.17E+02	-0.059	
22	4.43E-03	3.92E+02	4.01E+02	-2.217	

R: 152. X: 0. Y: 152. DL: 304. REQ: 169. CF: 1.0000
CLHZ ARRAY, 22 DATA POINTS, RAMP: 170.0 MICROSEC, DATA: MBL1S6
0207 100N 66NZ OPR L 7 10-
Ch.21 = 0.17 Ch.22 = 0.89 Ch.23 = 15 Ch.24 = 92
RMS LOG ERROR: 1.58E-02, ANTILOG YIELDS 3.7115 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.98				
P 2	-0.06	0.49			
P 3	0.01	-0.05	0.90		
T 1	-0.07	-0.31	0.02	0.73	
T 2	0.03	0.32	0.09	0.17	0.75
	P 1	P 2	P 3	T 1	T 2


MBL2S1
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
1931.
OHM-M
118. M
3.77
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 3.29
CALIBRATION: 1
OFFSET: 38 M
RAMP: 75.0

MBL2S1

MODEL: 2 LAYERS

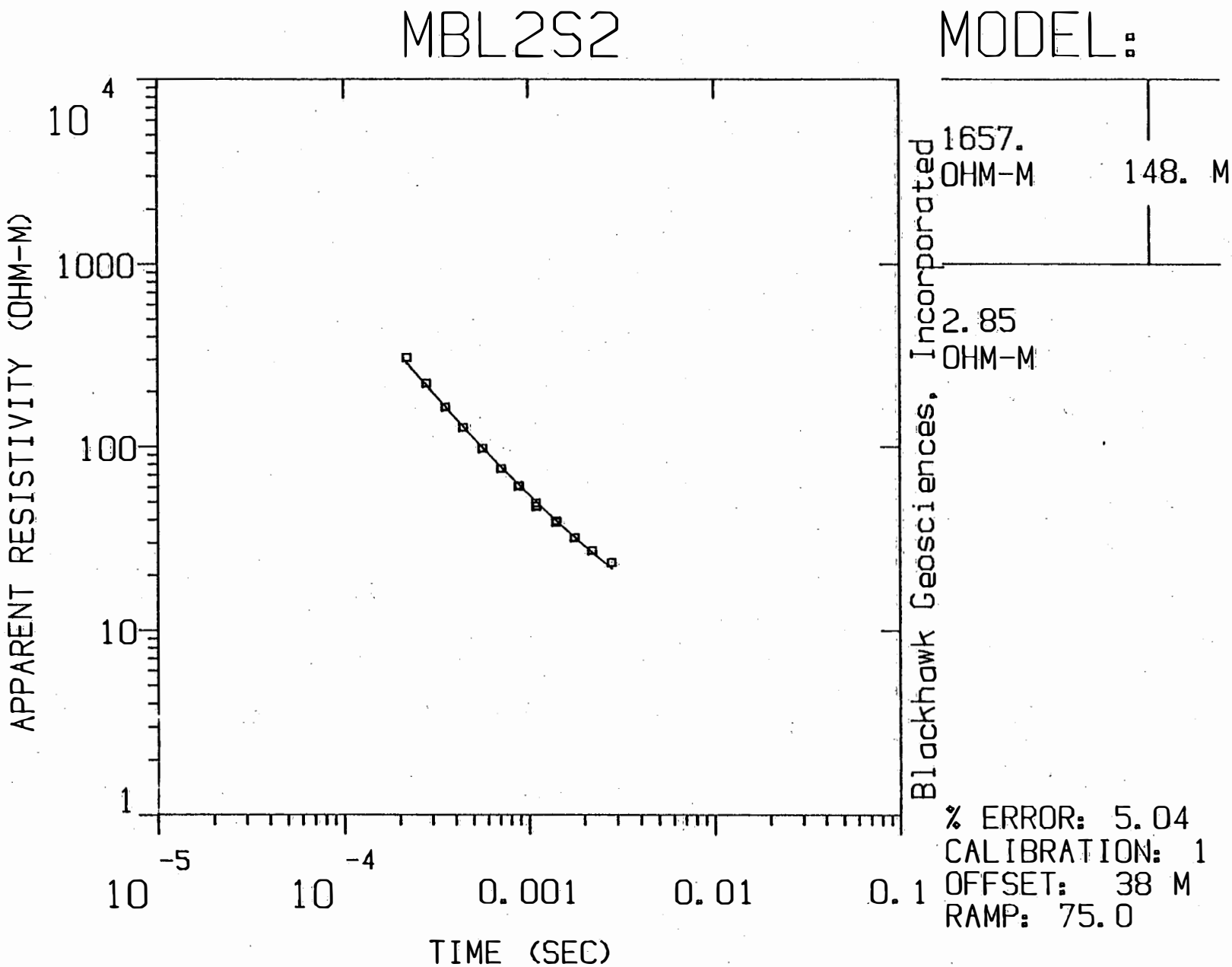
RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	(FEET)	CONDUCTANCE (S) LAYER	TOTAL
		114.9	377.0		
1931.42	118.3	-3.4	-11.2	0.1	0.1
3.77					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	1.40E-04	3.12E+02	2.96E+02	5.258	
2	1.77E-04	2.30E+02	2.24E+02	2.326	
3	2.20E-04	1.76E+02	1.75E+02	0.759	
4	2.80E-04	1.33E+02	1.34E+02	-0.447	
5	3.55E-04	1.02E+02	1.04E+02	-1.349	
6	4.43E-04	8.13E+01	8.26E+01	-1.609	
7	5.64E-04	6.45E+01	6.49E+01	-0.648	
8	7.13E-04	5.16E+01	5.20E+01	-0.746	
9	8.81E-04	4.22E+01	4.30E+01	-1.879	
10	8.90E-04	4.21E+01	4.27E+01	-1.296	
11	1.10E-03	3.53E+01	3.55E+01	-0.703	
12	1.10E-03	3.39E+01	3.54E+01	-4.202	
13	1.40E-03	2.85E+01	2.92E+01	-2.260	
14	1.41E-03	2.92E+01	2.90E+01	0.696	
15	1.77E-03	2.41E+01	2.43E+01	-0.720	
16	1.80E-03	2.48E+01	2.41E+01	3.047	
17	2.20E-03	2.06E+01	2.07E+01	-0.665	
18	2.80E-03	1.80E+01	1.76E+01	2.557	
19	3.55E-03	1.53E+01	1.50E+01	2.181	

R: 38. X: 0. Y: 38. DL: 76. REQ: 42. CF: 1.0000
CLHZ ARRAY, 19 DATA POINTS, RAMP: 75.0 MICROSEC, DATA: MBL2S1
0802 200N 1NZ OPR L 5 8 -TXL=76*76
Ch.21 = 0.075 Ch.22 = 0.89 Ch.23 = 19 Ch.24 = 5
RMS LOG ERROR: 1.41E-02, ANTILOG YIELDS 3.2943 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER
P 1 0.03
P 2 -0.09 0.34
T 1 -0.01 0.05 0.97
P 1 P 2 T 1


MBL2S2
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
1657.
OHM-M
148. M
2.85
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 5.04
CALIBRATION: 1
OFFSET: 38 M
RAMP: 75.0

MBL2S2

MODEL: 2 LAYERS

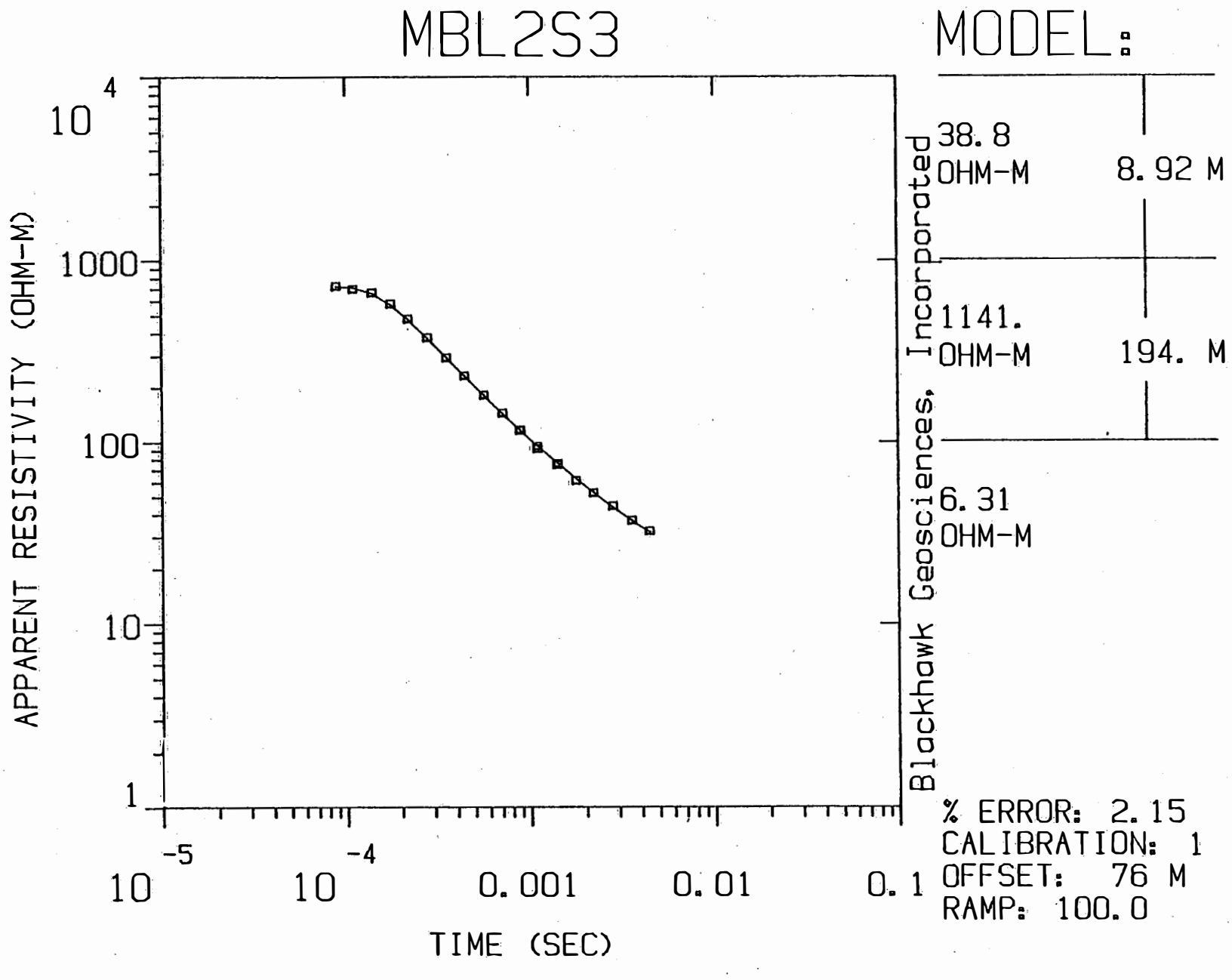
RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	(FEET)	CONDUCTANCE (S) LAYER	TOTAL
		144.8	475.0		
1656.55	147.8	-3.1	-10.0	0.1	0.1
2.85					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	2.20E-04	3.07E+02	2.87E+02	6.932	
2	2.80E-04	2.22E+02	2.16E+02	2.562	
3	3.55E-04	1.64E+02	1.64E+02	-0.129	
4	4.43E-04	1.27E+02	1.28E+02	-1.177	
5	5.64E-04	9.75E+01	9.87E+01	-1.210	
6	7.13E-04	7.57E+01	7.69E+01	-1.646	
7	8.81E-04	6.06E+01	6.21E+01	-2.519	
8	8.90E-04	6.11E+01	6.15E+01	-0.684	
9	1.10E-03	4.92E+01	5.01E+01	-1.879	
10	1.10E-03	4.72E+01	4.99E+01	-5.536	
11	1.40E-03	3.87E+01	3.97E+01	-2.482	
12	1.41E-03	3.94E+01	3.94E+01	-0.061	
13	1.77E-03	3.20E+01	3.22E+01	-0.578	
14	2.20E-03	2.72E+01	2.66E+01	2.160	
15	2.80E-03	2.34E+01	2.18E+01	7.319	

R: 38. X: 0. Y: 38. DL: 76. REQ: 42. CF: 1.0000
CLHZ ARRAY, 15 DATA POINTS, RAMP: 75.0 MICROSEC, DATA: MBL2S2
0802 200N 2NZ OPR L 5 10-
Ch.21 = 0.075 Ch.22 = 0.89 Ch.23 = 19 Ch.24 = 5
RMS LOG ERROR: 2.13E-02, ANTILOG YIELDS 5.0389 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER
P 1 0.05
P 2 -0.01 0.89
T 1 0.00 0.00 1.00
P 1 P 2 T 1


MBL2S3
MODEL:
APPARENT RESISTIVITY (OHM-M)
10 4
1000
100
10
1
10 -5
10 -4
0.001
0.01
0.1
TIME (SEC)
38.8
OHM-M
8.92 M
1141.
OHM-M
194. M
6.31
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 2.15
CALIBRATION: 1
OFFSET: 76 M
RAMP: 100.0

MBL2S3

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		175.0	574.0		
38.80	8.9	166.0	544.7	0.2	0.2
1141.01	194.1	-28.0	-91.9	0.2	0.4
6.31					

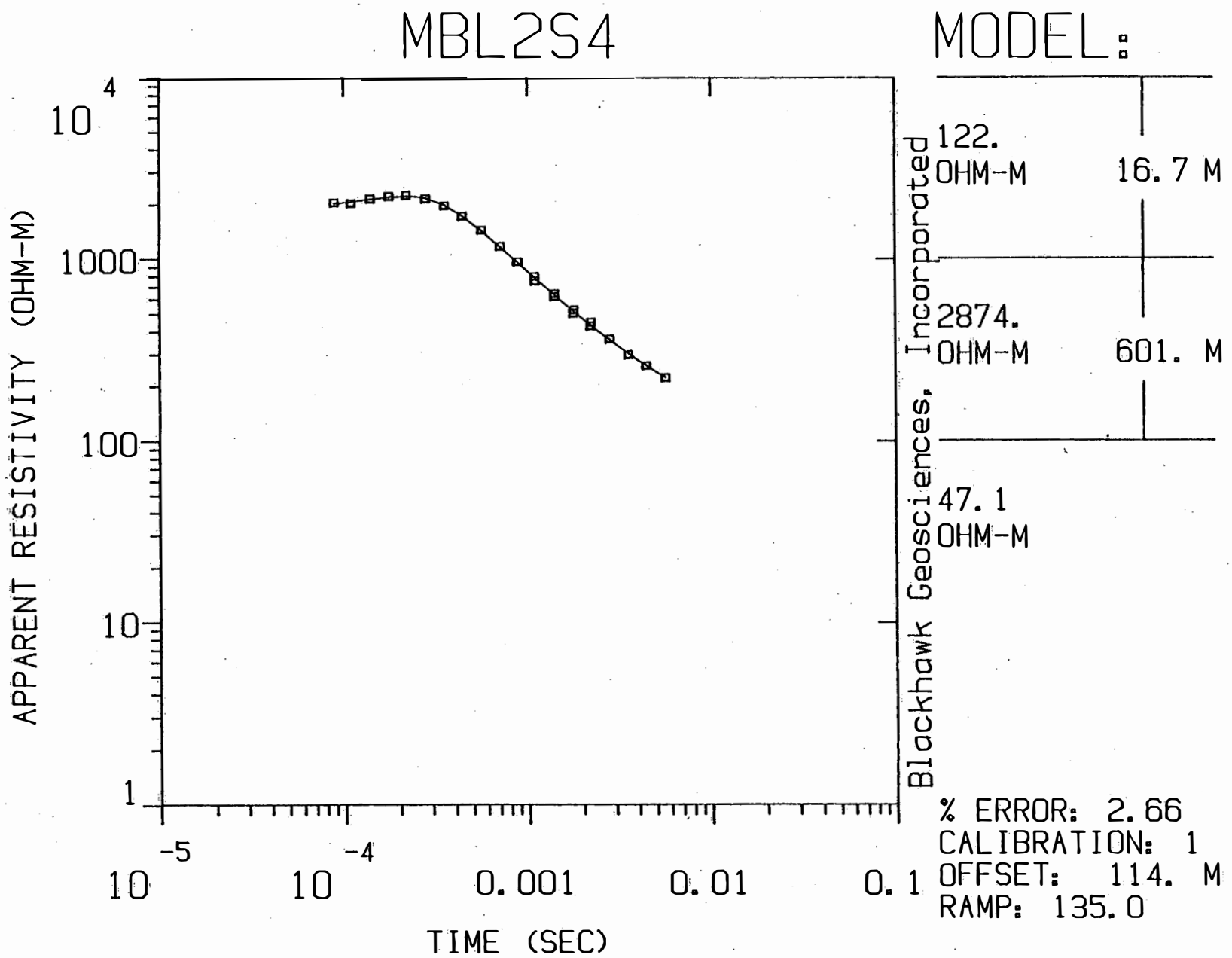
	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	7.23E+02	7.20E+02	0.485	
2	1.10E-04	6.97E+02	7.10E+02	-1.926	
3	1.40E-04	6.65E+02	6.59E+02	0.941	
4	1.77E-04	5.78E+02	5.70E+02	1.330	
5	2.20E-04	4.78E+02	4.74E+02	0.817	
6	2.80E-04	3.77E+02	3.74E+02	0.949	
7	3.55E-04	2.92E+02	2.92E+02	-0.050	
8	4.43E-04	2.32E+02	2.32E+02	0.089	
9	5.64E-04	1.81E+02	1.81E+02	0.309	
10	7.13E-04	1.45E+02	1.43E+02	1.124	
11	8.81E-04	1.16E+02	1.17E+02	-0.470	
12	8.90E-04	1.17E+02	1.15E+02	1.415	
13	1.10E-03	9.45E+01	9.51E+01	-0.635	
14	1.10E-03	9.16E+01	9.48E+01	-3.365	
15	1.40E-03	7.45E+01	7.64E+01	-2.452	
16	1.41E-03	7.59E+01	7.58E+01	0.049	
17	1.77E-03	6.11E+01	6.25E+01	-2.295	
18	2.20E-03	5.24E+01	5.24E+01	-0.126	
19	2.80E-03	4.44E+01	4.36E+01	1.791	
20	3.55E-03	3.70E+01	3.68E+01	0.525	
21	4.43E-03	3.23E+01	3.17E+01	1.827	

R: 76. X: 0. Y: 76. DL: 152. REQ: 84. CF: 1.0000
CLHZ ARRAY, 21 DATA POINTS, RAMP: 100.0 MICROSEC, DATA: MBL2S3
0802 200N 3NZ OPR L 5 10-TXL=152*152
Ch.21 = 0.1 Ch.22 = 0.89 Ch.23 = 15.5 Ch.24 = 2
RMS LOG ERROR: 9.23E-03, ANTILOG YIELDS 2.1477 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.39				
P 2	0.09	0.02			
P 3	-0.04	-0.02	0.25		
T 1	-0.40	-0.10	0.06	0.43	
T 2	0.03	0.02	0.02	0.01	0.97
	P 1	P 2	P 3	T 1	T 2


MBL2S4
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
122.
OHM-M
16.7 M
2874.
OHM-M
601. M
47.1
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 2.66
CALIBRATION: 1
OFFSET: 114. M
RAMP: 135.0

MBL2S4

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		254.8	836.0		
122.16	16.7	238.1	781.3	0.1	0.1
2874.18	600.9	-362.8	-1190.3	0.2	0.3
47.13					

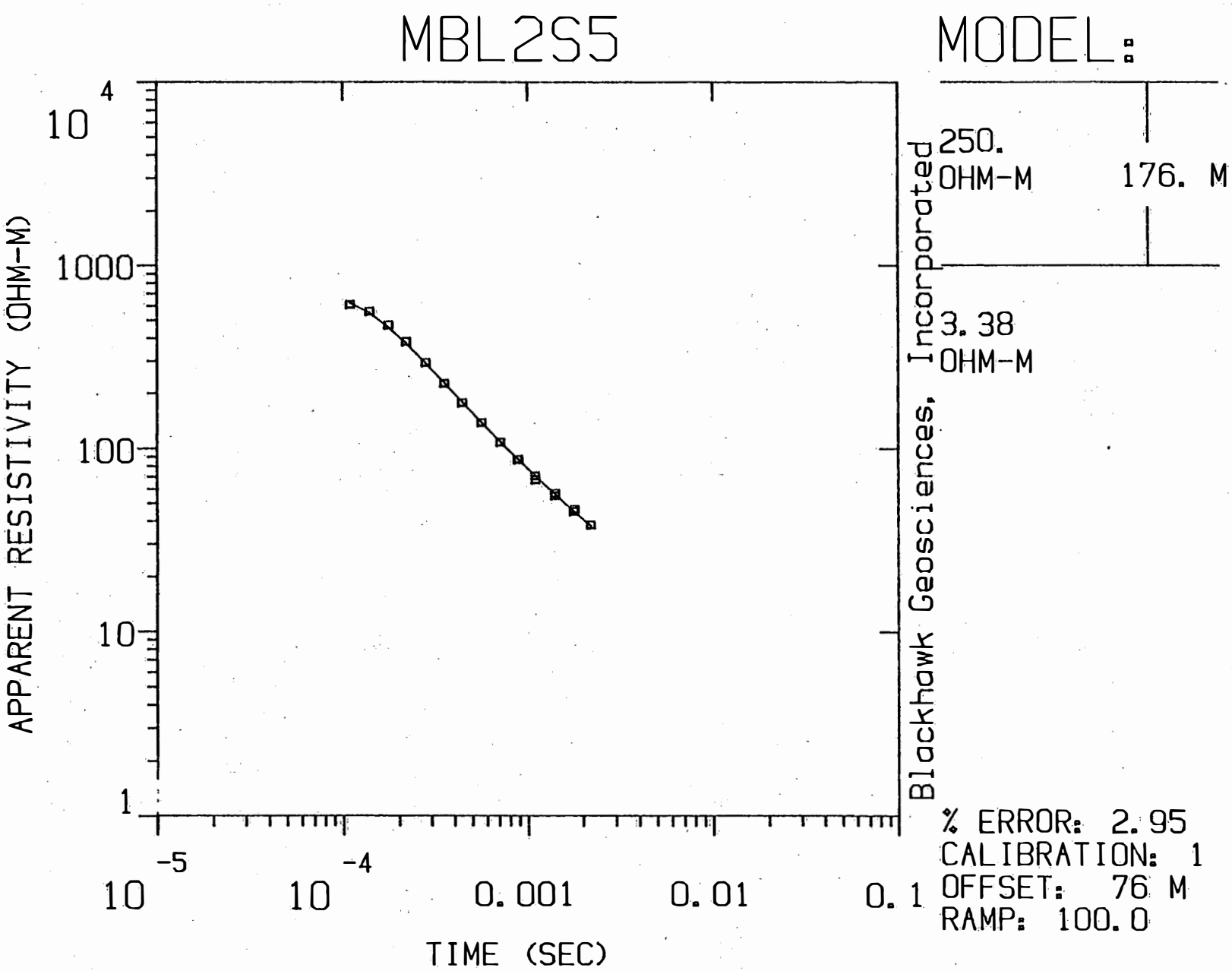
	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	2.06E+03	2.04E+03	0.863	
2	1.10E-04	2.05E+03	2.09E+03	-2.076	
3	1.40E-04	2.17E+03	2.16E+03	0.608	
4	1.77E-04	2.23E+03	2.22E+03	0.570	
5	2.20E-04	2.27E+03	2.25E+03	0.884	
6	2.80E-04	2.16E+03	2.18E+03	-0.786	
7	3.55E-04	1.98E+03	1.99E+03	-0.655	
8	4.43E-04	1.73E+03	1.74E+03	-0.511	
9	5.64E-04	1.44E+03	1.43E+03	0.782	
10	7.13E-04	1.17E+03	1.16E+03	0.735	
11	8.81E-04	9.62E+02	9.60E+02	0.167	
12	8.90E-04	9.63E+02	9.51E+02	1.226	
13	1.10E-03	7.96E+02	7.87E+02	1.077	
14	1.10E-03	7.54E+02	7.85E+02	-3.910	
15	1.40E-03	6.20E+02	6.35E+02	-2.366	
16	1.41E-03	6.42E+02	6.30E+02	1.886	
17	1.77E-03	5.04E+02	5.19E+02	-2.924	
18	1.80E-03	5.24E+02	5.13E+02	2.262	
19	2.20E-03	4.29E+02	4.34E+02	-1.345	
20	2.22E-03	4.49E+02	4.31E+02	4.339	
21	2.80E-03	3.63E+02	3.60E+02	0.874	
22	3.55E-03	2.98E+02	3.02E+02	-1.477	
23	4.43E-03	2.58E+02	2.59E+02	-0.300	
24	5.64E-03	2.22E+02	2.22E+02	-0.057	

R: 114. X: 0. Y: 115. DL: 229. REQ: 128. CF: 1.0000
CLHZ ARRAY, 24 DATA POINTS, RAMP: 135.0 MICROSEC, DATA: MBL2S4
0902 200N 44NZ OPR L 6 10-
Ch.21 = 0.135 Ch.22 = 0.89 Ch.23 = 14.5 Ch.24 =
RMS LOG ERROR: 1.14E-02, ANTILOG YIELDS 2.6616 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.56				
P 2	0.00	0.57			
P 3	0.03	-0.07	0.91		
T 1	-0.44	-0.20	0.00	0.47	
T 2	0.01	0.02	0.01	0.02	1.00
	P 1	P 2	P 3	T 1	T 2


MBL2S5
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
250.
OHM-M
176. M
3.38
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 2.95
CALIBRATION: 1
OFFSET: 76 M
RAMP: 100.0

MBL2S5

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		170.1	558.0		
250.03	176.4	-6.3	-20.8	0.7	0.7
3.38					

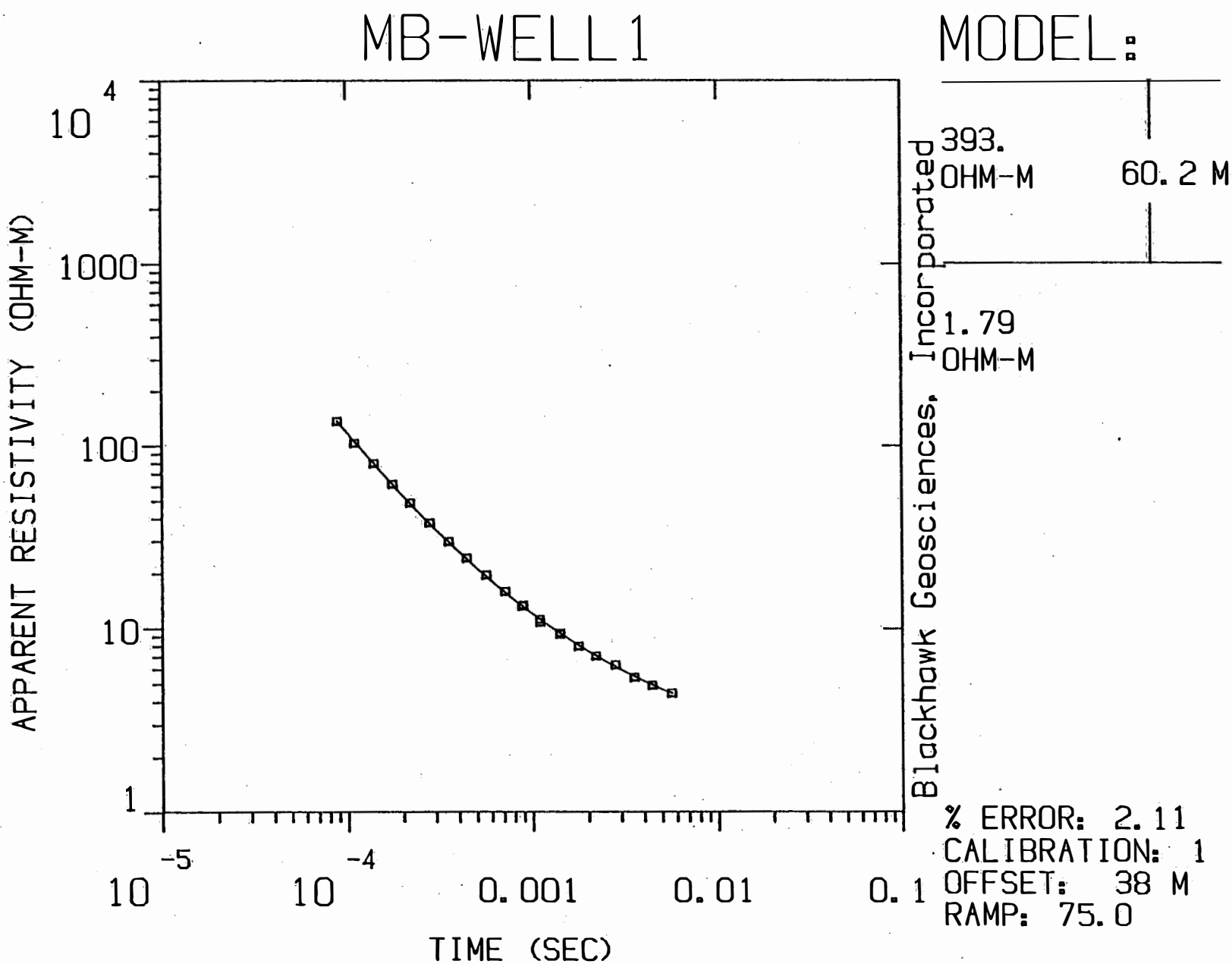
	TIMES	DATA	CALC	% ERROR	STD ERR
1	1.10E-04	6.08E+02	6.24E+02	-2.534	
2	1.40E-04	5.57E+02	5.47E+02	1.728	
3	1.77E-04	4.69E+02	4.58E+02	2.349	
4	2.20E-04	3.82E+02	3.75E+02	1.900	
5	2.80E-04	2.94E+02	2.93E+02	0.540	
6	3.55E-04	2.26E+02	2.27E+02	-0.657	
7	4.43E-04	1.77E+02	1.79E+02	-1.043	
8	5.64E-04	1.38E+02	1.39E+02	-0.426	
9	7.13E-04	1.08E+02	1.09E+02	-0.604	
10	8.81E-04	8.69E+01	8.76E+01	-0.849	
11	8.90E-04	8.69E+01	8.68E+01	0.177	
12	1.10E-03	7.06E+01	7.07E+01	-0.132	
13	1.10E-03	6.72E+01	7.04E+01	-4.555	
14	1.40E-03	5.48E+01	5.60E+01	-2.030	
15	1.41E-03	5.66E+01	5.56E+01	1.850	
16	1.77E-03	4.50E+01	4.52E+01	-0.422	
17	1.80E-03	4.63E+01	4.46E+01	3.708	
18	2.20E-03	3.80E+01	3.74E+01	1.799	

R: 76. X: 0. Y: 76. DL: 152. REQ: 84. CF: 1.0000
CLHZ ARRAY, 18 DATA POINTS, RAMP: 100.0 MICROSEC, DATA: MBL2S5
0902 200N 5NZ OPR L 5 10-TXP=5
Ch.21 = 0.1 Ch.22 = 0.89 Ch.23 = 15 Ch.24 = 231
RMS LOG ERROR: 1.26E-02, ANTILOG YIELDS 2.9478 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	1.00		
P 2	0.00	1.00	
T 1	0.00	0.00	1.00
	P 1	P 2	T 1


MB-WELL1
MODEL:
APPARENT RESISTIVITY (OHM-M)
10 4
1000
100
10
1
10 -5
10 -4
0.001
0.01
0.1
TIME (SEC)
393.
OHM-M
60.2 M
1.79
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 2.11
CALIBRATION: 1
OFFSET: 38 M
RAMP: 75.0

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		59.7	196.0		
393.42	60.2	-0.5	-1.6	0.2	0.2
1.79					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	1.36E+02	1.37E+02	-0.283	
2	1.10E-04	1.03E+02	1.06E+02	-2.691	
3	1.40E-04	7.97E+01	7.98E+01	-0.152	
4	1.77E-04	6.14E+01	6.12E+01	0.403	
5	2.20E-04	4.87E+01	4.82E+01	0.936	
6	2.80E-04	3.78E+01	3.75E+01	1.015	
7	3.55E-04	2.98E+01	2.95E+01	0.934	
8	4.43E-04	2.42E+01	2.39E+01	1.272	
9	5.64E-04	1.96E+01	1.92E+01	1.954	
10	7.13E-04	1.59E+01	1.57E+01	1.331	
11	8.81E-04	1.32E+01	1.32E+01	-0.013	
12	8.90E-04	1.34E+01	1.31E+01	2.063	
13	1.10E-03	1.12E+01	1.12E+01	-0.198	
14	1.10E-03	1.08E+01	1.12E+01	-3.317	
15	1.40E-03	9.28E+00	9.41E+00	-1.395	
16	1.41E-03	9.41E+00	9.36E+00	0.445	
17	1.77E-03	7.97E+00	8.07E+00	-1.174	
18	2.20E-03	7.05E+00	7.06E+00	-0.211	
19	2.80E-03	6.30E+00	6.16E+00	2.203	
20	3.55E-03	5.40E+00	5.45E+00	-0.946	
21	4.43E-03	4.89E+00	4.91E+00	-0.483	
22	5.64E-03	4.44E+00	4.42E+00	0.418	

R: 38. X: 0. Y: 38. DL: 76. REQ: 42. CF: 1.0000
CLHZ ARRAY, 22 DATA POINTS, RAMP: 75.0 MICROSEC, DATA: MB-WELL1
0902 200N 6NZ OPR L 5 8 -TXP=6
Ch.21 = 0.075 Ch.22 = 0.89 Ch.23 = 19 Ch.24 = 5
RMS LOG ERROR: 9.09E-03, ANTILOG YIELDS 2.1145 %
LATE TIME PARAMETERS

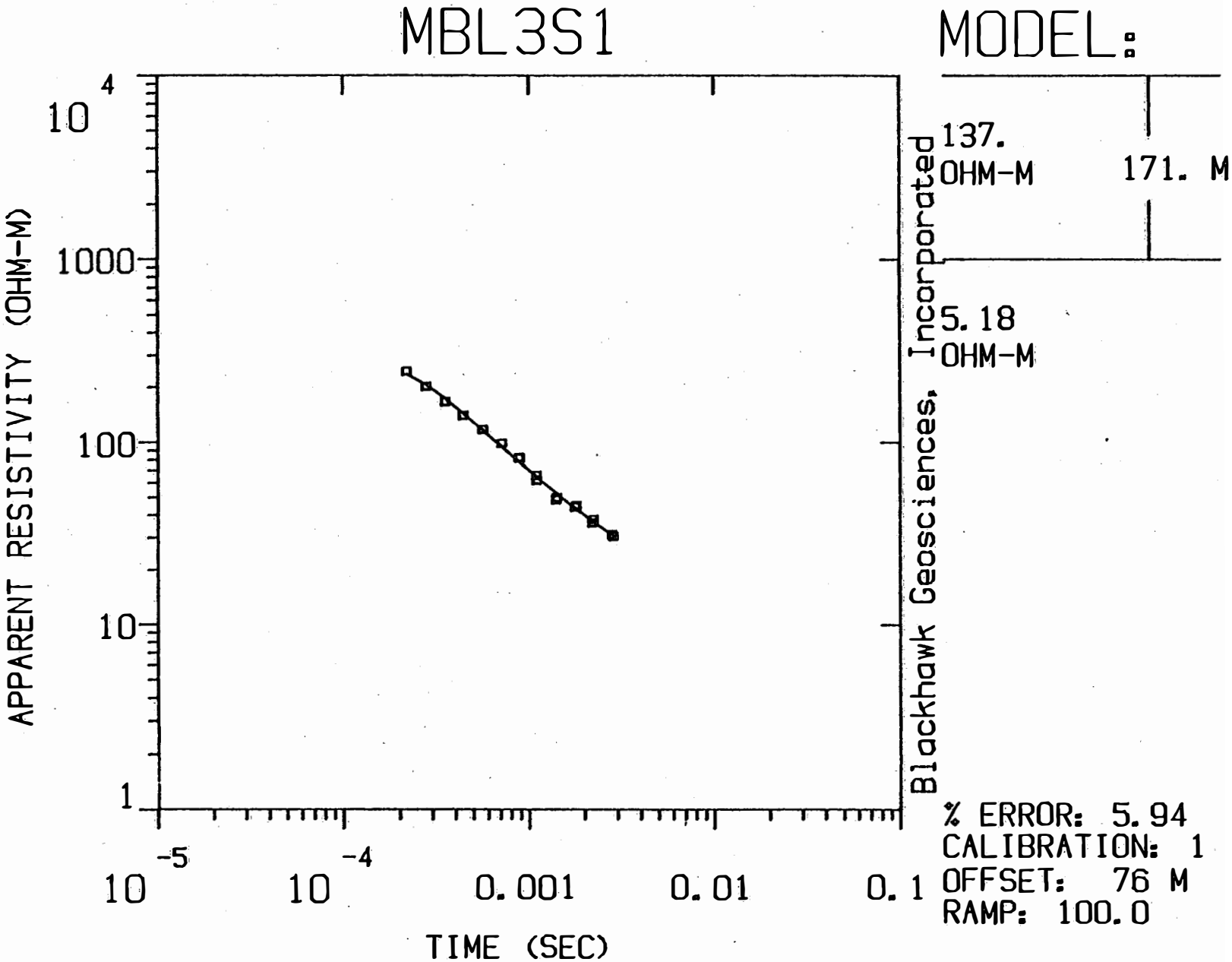
* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.13		
P 2	-0.01	1.00	
T 1	0.01	0.00	1.00
	P 1	P 2	T 1

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	164.535	393.419	1233.472
	2	1.717	1.788	1.891
THICK	1	59.459	60.242	60.810
DEPTH	1	59.459	60.242	60.810


MBL3S1
MODEL:
137.
OHM-M
171. M
5.18
OHM-M
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
Blackhawk Geosciences, Incorporated
% ERROR: 5.94
CALIBRATION: 1
OFFSET: 76 M
RAMP: 100.0

MBL3S1

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		150.0	492.0		
136.75	171.0	-21.0	-69.0	1.3	1.3
5.18					

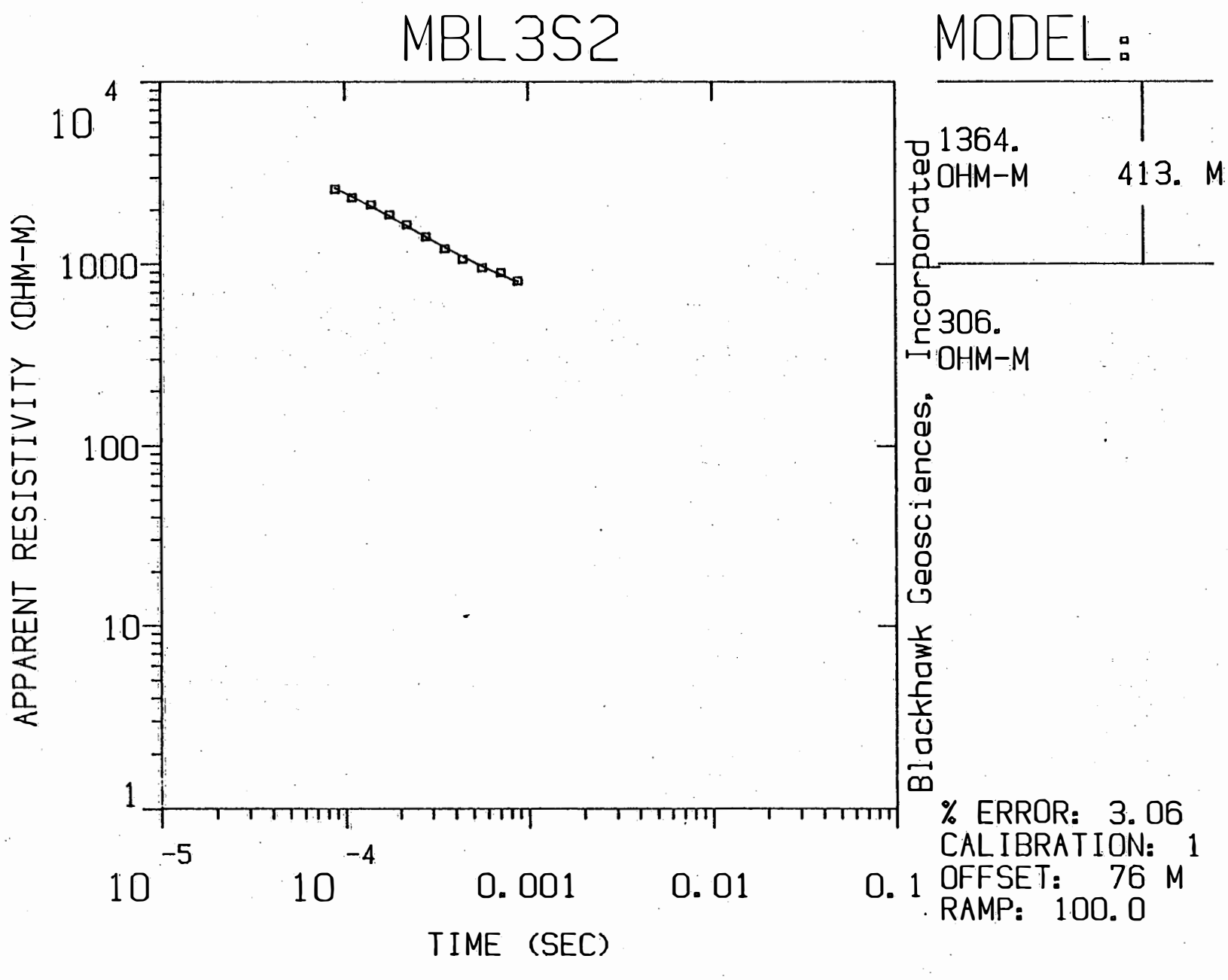
	TIMES	DATA	CALC	% ERROR	STD ERR
1	2.20E-04	2.44E+02	2.37E+02	3.217	
2	2.80E-04	2.01E+02	2.06E+02	-2.289	
3	3.55E-04	1.66E+02	1.73E+02	-3.951	
4	4.43E-04	1.40E+02	1.44E+02	-2.850	
5	5.64E-04	1.17E+02	1.16E+02	0.781	
6	7.13E-04	9.84E+01	9.41E+01	4.566	
7	8.81E-04	8.22E+01	7.80E+01	5.447	
8	8.90E-04	8.17E+01	7.73E+01	5.705	
9	1.10E-03	6.56E+01	6.45E+01	1.674	
10	1.10E-03	6.18E+01	6.43E+01	-4.013	
11	1.40E-03	4.84E+01	5.26E+01	-7.922	
12	1.41E-03	4.97E+01	5.23E+01	-4.951	
13	1.77E-03	4.41E+01	4.36E+01	1.091	
14	1.80E-03	4.50E+01	4.31E+01	4.413	
15	2.20E-03	3.61E+01	3.70E+01	-2.263	
16	2.22E-03	3.77E+01	3.67E+01	2.738	
17	2.80E-03	3.13E+01	3.11E+01	0.517	
18	2.85E-03	3.05E+01	3.07E+01	-0.845	

R: 76. X: 0. Y: 76. DL: 152. REQ: 84. CF: 1.0000
CLHZ ARRAY, 18 DATA POINTS, RAMP: 100.0 MICROSEC, DATA: MBL3S1
1002 300N 100NZ OPR L 5 10-TXL=152*152
Ch.21 = 0.1 Ch.22 = 0.89 Ch.23 = 15 Ch.24 = 231
RMS LOG ERROR: 2.51E-02, ANTILOG YIELDS 5.9386 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	1.00		
P 2	0.00	1.00	
T 1	0.00	0.00	1.00
	P 1	P 2	T 1


MBL3S2
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
1364.
OHM-M
413. M
306.
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 3.06
CALIBRATION: 1
OFFSET: 76 M
RAMP: 100.0

MBL3S2

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		246.9	810.0		
1363.71	413.0	-166.1	-545.0	0.3	0.3
306.13					

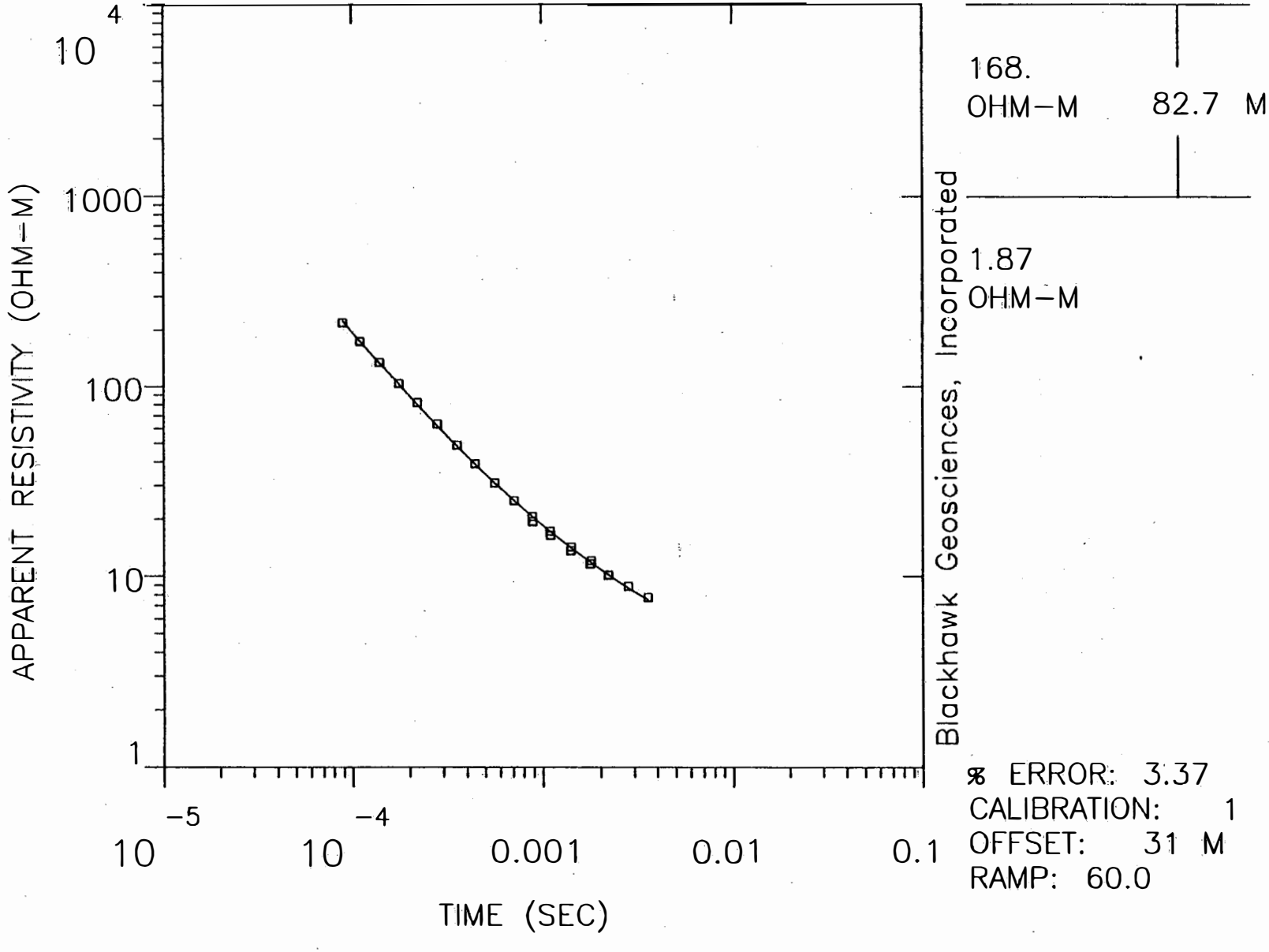
	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	2.61E+03	2.64E+03	-1.194	
2	1.10E-04	2.34E+03	2.37E+03	-1.492	
3	1.40E-04	2.14E+03	2.09E+03	2.112	
4	1.77E-04	1.88E+03	1.84E+03	2.059	
5	2.20E-04	1.65E+03	1.62E+03	1.833	
6	2.80E-04	1.42E+03	1.41E+03	0.186	
7	3.55E-04	1.22E+03	1.24E+03	-1.927	
8	4.43E-04	1.07E+03	1.10E+03	-3.422	
9	5.64E-04	9.53E+02	9.72E+02	-1.964	
10	7.13E-04	8.95E+02	8.71E+02	2.776	
11	8.81E-04	8.07E+02	7.97E+02	1.272	

R: 76. X: 0. Y: 76. DL: 152. REQ: 84. CF: 1.0000
CLHZ ARRAY, 11 DATA POINTS, RAMP: 100.0 MICROSEC, DATA: MBL3S2
1002 300N 222NZ OPR H 4 8 -
Ch.21 = 0.1 Ch.22 = 0.089 Ch.23 = 15 Ch.24 = 23
RMS LOG ERROR: 1.31E-02, ANTILOG YIELDS 3.0630 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

	P 1	P 2	T 1
P 1	1.00		
P 2	-0.01	0.95	
T 1	0.01	0.02	0.99



MODEL:

168.
OHM-M

82.7 M

1.87
OHM-M

% ERROR: 3.37
CALIBRATION: 1
OFFSET: 31 M
RAMP: 60.0

NSL1S1

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		54.9	180.0		
167.80	82.7	-27.9	-91.4	0.5	0.5
1.87					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	2.18E+02	2.23E+02	-2.227	
2	1.10E-04	1.74E+02	1.74E+02	0.019	
3	1.40E-04	1.34E+02	1.33E+02	0.913	
4	1.77E-04	1.04E+02	1.02E+02	1.475	
5	2.20E-04	8.20E+01	8.04E+01	1.957	
6	2.80E-04	6.36E+01	6.21E+01	2.481	
7	3.55E-04	4.91E+01	4.87E+01	0.756	
8	4.43E-04	3.91E+01	3.89E+01	0.553	
9	5.64E-04	3.10E+01	3.09E+01	0.354	
10	7.13E-04	2.50E+01	2.49E+01	0.353	
11	8.81E-04	2.07E+01	2.06E+01	0.239	
12	8.90E-04	1.94E+01	2.05E+01	-4.955	
13	1.10E-03	1.73E+01	1.72E+01	0.279	
14	1.10E-03	1.64E+01	1.72E+01	-4.561	
15	1.40E-03	1.37E+01	1.42E+01	-3.296	
16	1.41E-03	1.43E+01	1.41E+01	1.274	
17	1.77E-03	1.17E+01	1.19E+01	-1.782	
18	1.80E-03	1.21E+01	1.18E+01	2.927	
19	2.20E-03	1.02E+01	1.02E+01	-0.418	
20	2.80E-03	8.90E+00	8.71E+00	2.283	
21	3.55E-03	7.77E+00	7.57E+00	2.562	

R: 31. X: 0. Y: 31. DL: 62. REQ: 34. CF: 1.0000
CLHZ ARRAY, 21 DATA POINTS, RAMP: 60.0 MICROSEC, DATA: NSL1S1
1308 NS 100WZ OPR XTL L 4 8 -100
Ch.21 = 0.06 Ch.22 = 0.89 Ch.23 = 20 Ch.24 = 38
RMS LOG ERROR: 1.44E-02, ANTILOG YIELDS 3.3734 %
LATE TIME PARAMETERS

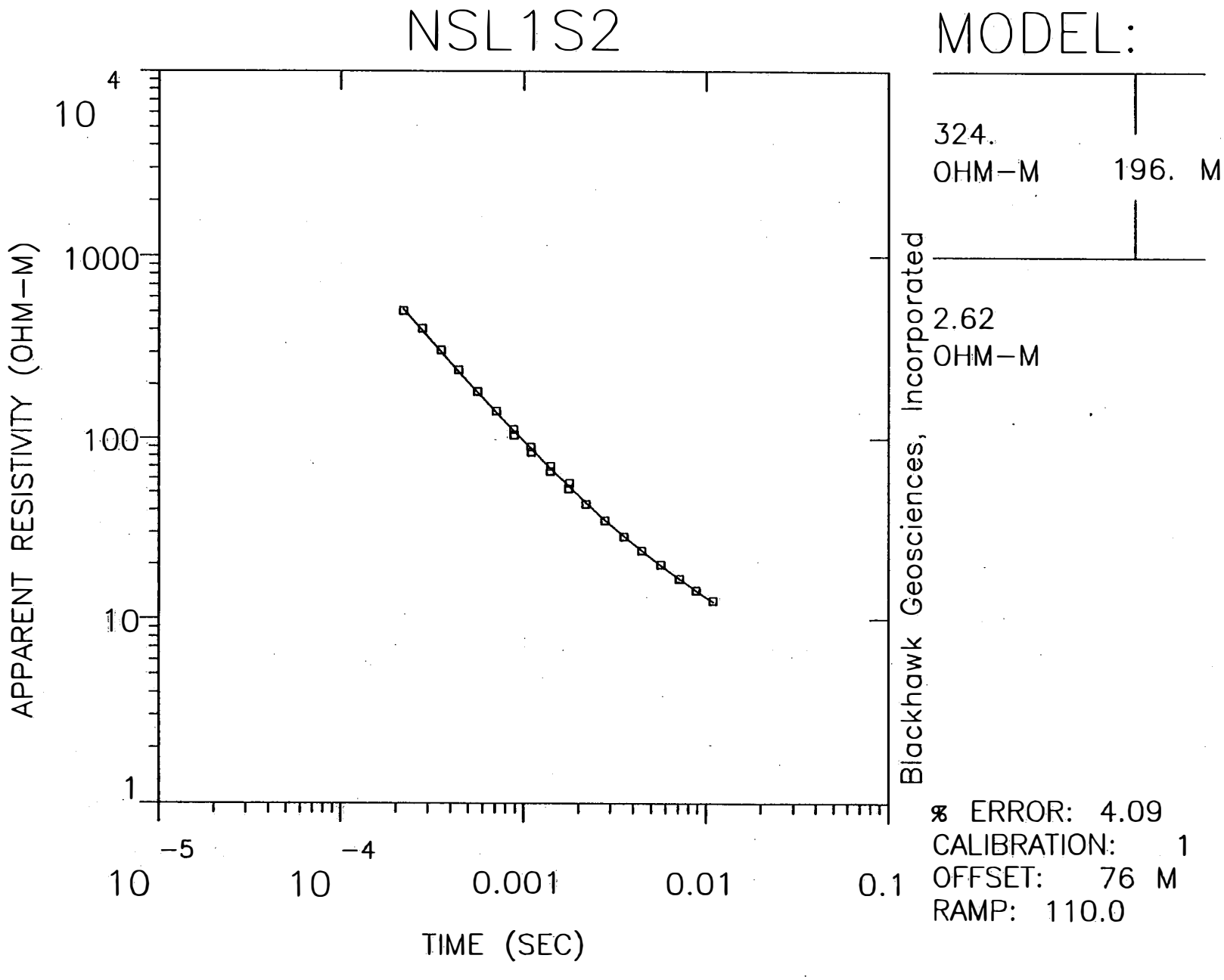
* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER
P 1 0.94
P 2 -0.01 1.00
T 1 0.00 0.00 1.00
P 1 P 2 T 1

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	119.197	167.803	391.784
	2	1.731	1.870	2.089

THICK	1	80.434	82.730	83.864
DEPTH	1	80.434	82.730	83.864


NSL1S2
MODEL:
324.
OHM-M
196. M
2.62
OHM-M
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
Blackhawk Geosciences, Incorporated
% ERROR: 4.09
CALIBRATION: 1
OFFSET: 76 M
RAMP: 110.0

NSL1S2

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		160.9	528.0		
324.29	196.0	-35.1	-115.1	0.6	0.6
2.62					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	2.20E-04	5.07E+02	5.16E+02	-1.846	
2	2.80E-04	4.05E+02	3.98E+02	1.658	
3	3.55E-04	3.09E+02	3.02E+02	2.131	
4	4.43E-04	2.41E+02	2.36E+02	2.066	
5	5.64E-04	1.83E+02	1.80E+02	1.338	
6	7.13E-04	1.42E+02	1.39E+02	1.855	
7	8.81E-04	1.12E+02	1.11E+02	1.636	
8	8.90E-04	1.04E+02	1.09E+02	-4.749	
9	1.10E-03	8.96E+01	8.81E+01	1.670	
10	1.10E-03	8.35E+01	8.78E+01	-4.809	
11	1.40E-03	6.55E+01	6.83E+01	-4.185	
12	1.41E-03	7.00E+01	6.78E+01	3.255	
13	1.77E-03	5.24E+01	5.42E+01	-3.285	
14	1.80E-03	5.66E+01	5.35E+01	5.765	
15	2.20E-03	4.30E+01	4.41E+01	-2.534	
16	2.80E-03	3.49E+01	3.53E+01	-0.944	
17	3.55E-03	2.84E+01	2.87E+01	-1.313	
18	4.43E-03	2.38E+01	2.38E+01	-0.091	
19	5.64E-03	1.99E+01	1.97E+01	0.885	
20	7.13E-03	1.67E+01	1.66E+01	0.481	
21	8.81E-03	1.43E+01	1.43E+01	0.281	
22	1.10E-02	1.26E+01	1.24E+01	1.451	

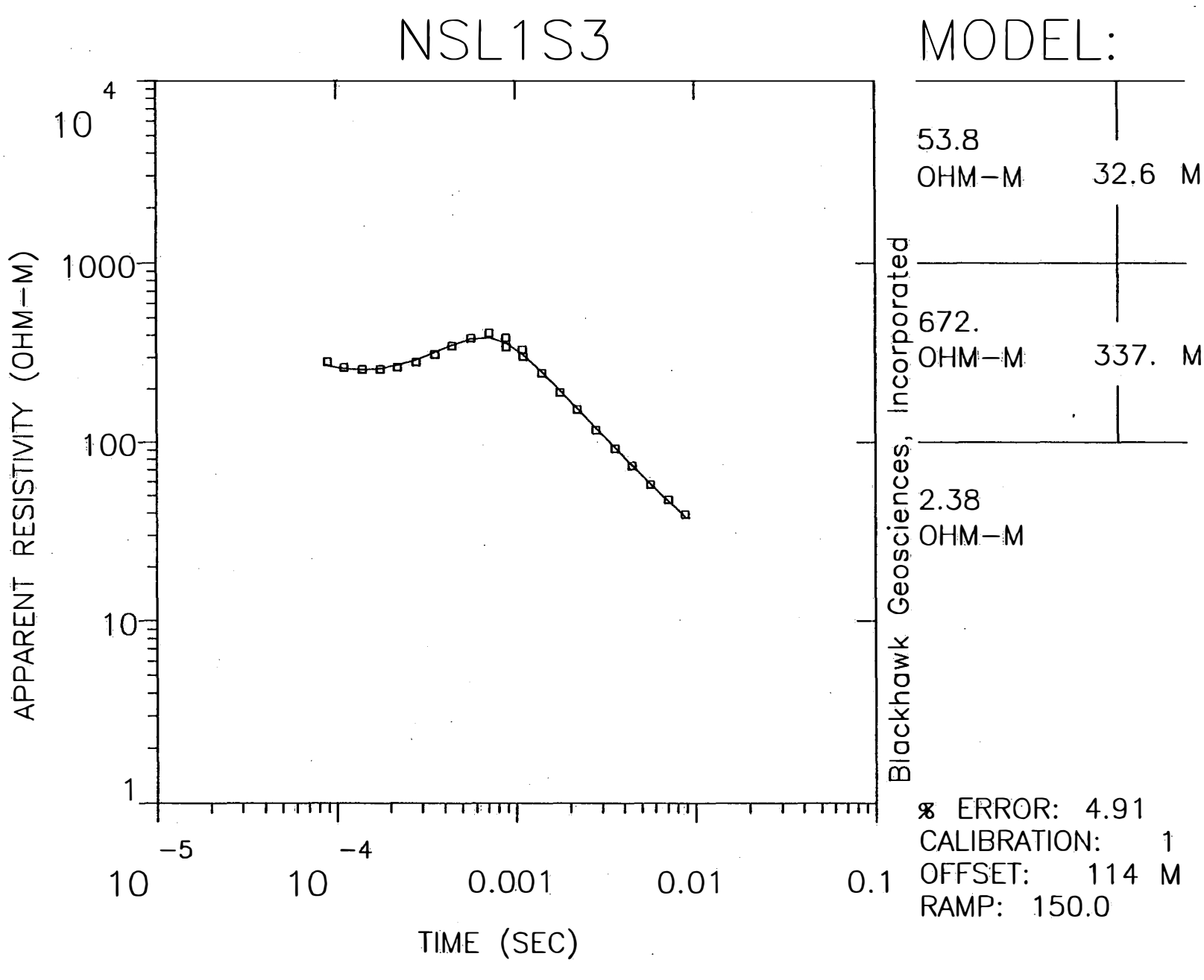
R: 76. X: 0. Y: 76. DL: 152. REQ: 84. CF: 1.0000
CLHZ ARRAY, 22 DATA POINTS, RAMP: 110.0 MICROSEC, DATA: NSL1S2
1308 NS 200WZ OPR XTL L 5 8 -100 152*152
Ch.21 = 0.11 Ch.22 = 0.89 Ch.23 = 19 Ch.24 = 23
RMS LOG ERROR: 1.74E-02, ANTILOG YIELDS 4.0857 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" ME NS FIXED PARAMETER
P 1 0.99
P 2 0.00 1.00
T 1 0.00 0.00 1.00
P 1 P 2 T 1

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	265.731	324.291	466.979
	2	2.330	2.622	2.972
THICK	1	192.841	196.031	198.464
DEPTH	1	192.841	196.031	198.464


NSL1S3
MODEL:
APPARENT RESISTIVITY (OHM-M)
10 4
1000
100
10
1
10 -5
10 -4
0.001
0.01
0.1
TIME (SEC)
53.8
OHM-M
32.6 M
672.
OHM-M
337. M
2.38
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 4.91
CALIBRATION: 1
OFFSET: 114 M
RAMP: 150.0

NSL1S3

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		312.1	1024.0		
53.80	32.6	279.5	917.0	0.6	0.6
672.35	336.8	-57.3	-187.9	0.5	1.1
2.38					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	2.84E+02	2.70E+02	5.266	
2	1.10E-04	2.65E+02	2.60E+02	1.909	
3	1.40E-04	2.57E+02	2.56E+02	0.294	
4	1.77E-04	2.57E+02	2.60E+02	-1.383	
5	2.20E-04	2.63E+02	2.71E+02	-2.817	
6	2.80E-04	2.83E+02	2.91E+02	-2.720	
7	3.55E-04	3.11E+02	3.20E+02	-2.789	
8	4.43E-04	3.49E+02	3.51E+02	-0.751	
9	5.64E-04	3.85E+02	3.81E+02	0.860	
10	7.13E-04	4.12E+02	3.87E+02	6.234	
11	8.81E-04	3.86E+02	3.62E+02	6.800	
12	8.90E-04	3.44E+02	3.60E+02	-4.480	
13	1.10E-03	3.32E+02	3.12E+02	6.357	
14	1.10E-03	3.03E+02	3.11E+02	-2.424	
15	1.40E-03	2.46E+02	2.49E+02	-1.221	
16	1.77E-03	1.90E+02	1.95E+02	-2.561	
17	2.20E-03	1.53E+02	1.55E+02	-1.059	
18	2.80E-03	1.17E+02	1.20E+02	-2.334	
19	3.55E-03	9.17E+01	9.34E+01	-1.800	
20	4.43E-03	7.37E+01	7.44E+01	-0.901	
21	5.64E-03	5.78E+01	5.84E+01	-1.054	
22	7.13E-03	4.75E+01	4.65E+01	2.137	
23	8.81E-03	3.93E+01	3.82E+01	2.962	

R: 114. X: 0. Y: 114. DL: 228. REQ: 127. CF: 1.0000
CLHZ ARRAY, 23 DATA POINTS, RAMP: 150.0 MICROSEC, DATA: NSL1S3
1308 NS 300NZ OPR XTL L 6 8 -100 228*228
Ch.21 = 0.15 Ch.22 = 0.89 Ch.23 = 18 Ch.24 = 51
RMS LOG ERROR: 2.08E-02, ANTILOG YIELDS 4.9122 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

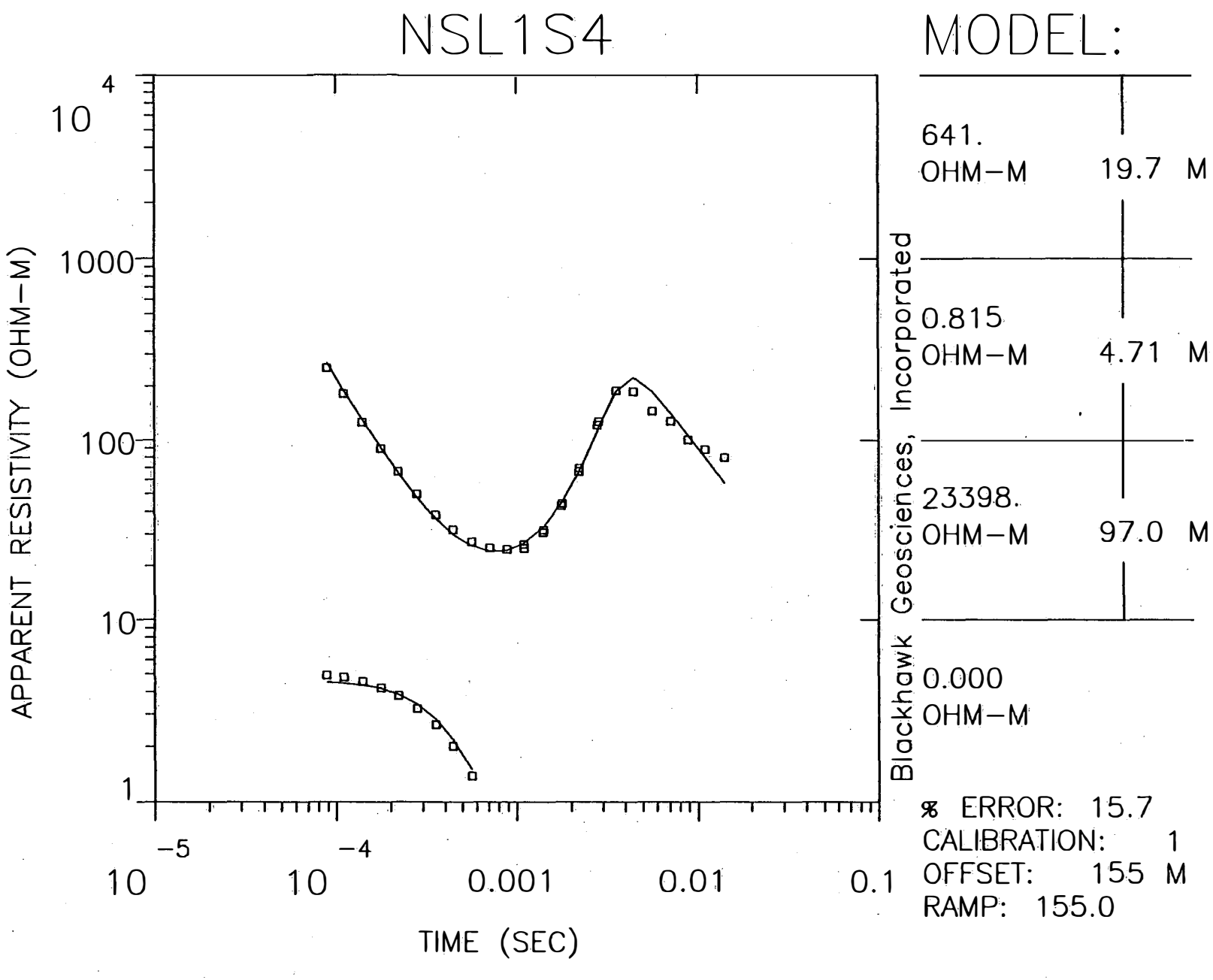
PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.81				
P 2	-0.15	0.33			
P 3	0.08	-0.07	0.72		
T 1	-0.26	-0.31	0.09	0.62	
T 2	0.03	0.03	-0.02	0.04	0.99

P 1 P 2 P 3 T 1 T 2

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	40.340	53.799	77.589
	2	534.819	672.351	1039.174
	3	1.686	2.377	2.822
THICK	1	22.055	32.607	55.758
	2	311.711	336.787	351.236
DEPTH	1	22.055	32.607	55.758
	2	364.542	369.394	374.821


NSL1S4
APPARENT RESISTIVITY (OHM-M)
10 4
1000
100
10
1
10 -5
10 -4
0.001
0.01
0.1
TIME (SEC)
MODEL:
641.
OHM-M
19.7 M
0.815
OHM-M
4.71 M
23398.
OHM-M
97.0 M
0.000
OHM-M
% ERROR: 15.7
CALIBRATION: 1
OFFSET: 155 M
RAMP: 155.0
Blackhawk Geosciences, Incorporated

NSL1S4

MODEL: 4 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	(FEET)	CONDUCTANCE (S) LAYER	TOTAL
		405.1	1329.0		
640.55	19.7	385.4	1264.5	0.0	0.0
0.81	4.7	380.7	1249.0	5.8	5.8
23397.60	97.0	283.7	930.7	0.0	5.8
0.00					

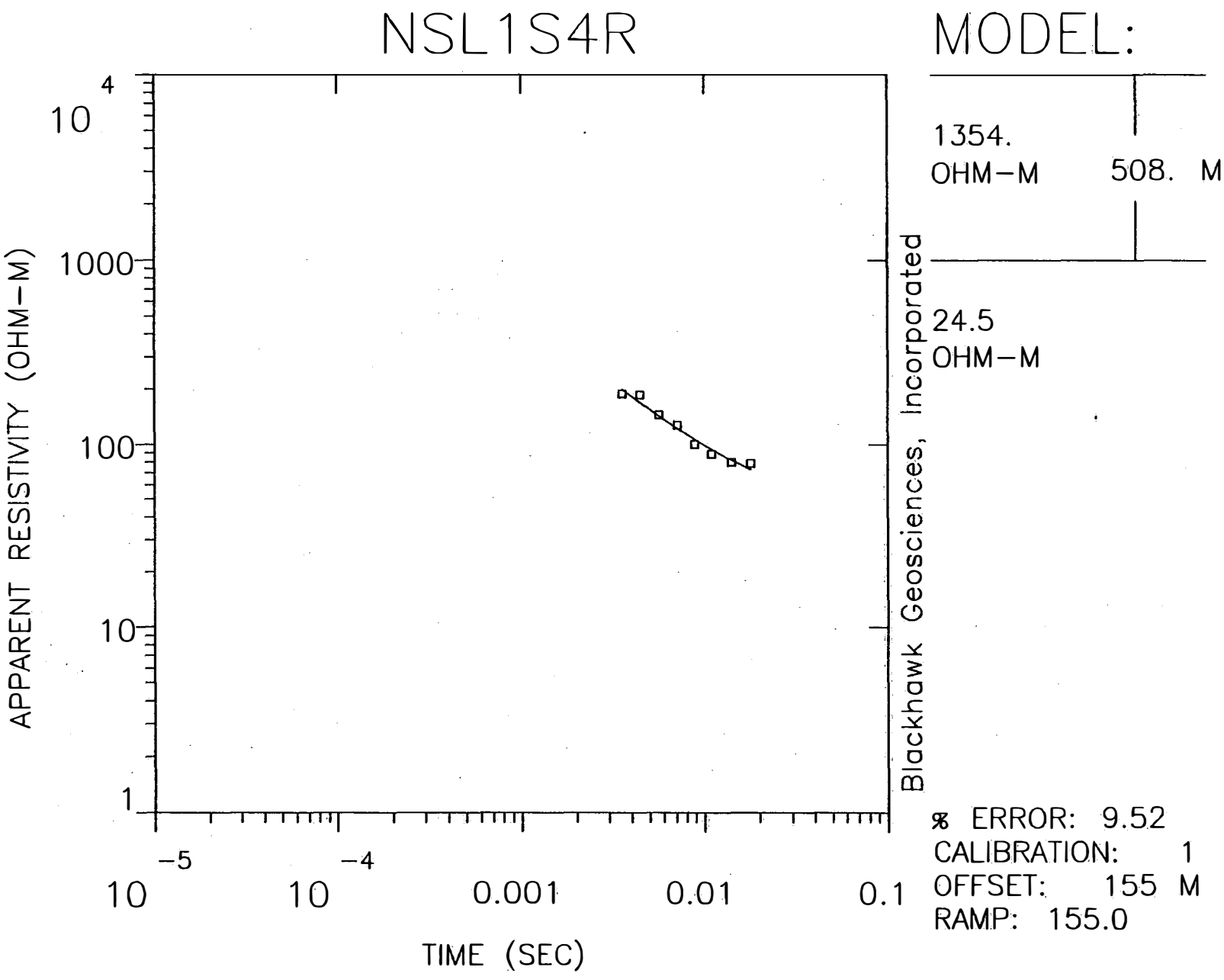
	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	2.53E+02	2.69E+02	-5.918	
2	1.10E-04	1.81E+02	1.90E+02	-4.891	
3	1.40E-04	1.26E+02	1.29E+02	-2.807	
4	1.77E-04	8.98E+01	9.03E+01	-0.623	
5	2.20E-04	6.68E+01	6.59E+01	1.324	
6	2.80E-04	4.99E+01	4.80E+01	3.936	
7	3.55E-04	3.84E+01	3.67E+01	4.710	
8	4.43E-04	3.17E+01	3.00E+01	5.881	
9	5.64E-04	2.72E+01	2.58E+01	5.586	
10	7.13E-04	2.51E+01	2.40E+01	4.527	
11	8.81E-04	2.47E+01	2.43E+01	1.452	
12	8.90E-04	2.46E+01	2.44E+01	0.848	
13	1.10E-03	2.63E+01	2.67E+01	-1.529	
14	1.10E-03	2.50E+01	2.67E+01	-6.393	
15	1.40E-03	3.05E+01	3.28E+01	-6.821	
16	1.41E-03	3.16E+01	3.31E+01	-4.473	
17	1.77E-03	4.31E+01	4.46E+01	-3.516	
18	1.80E-03	4.41E+01	4.56E+01	-3.298	
19	2.20E-03	6.68E+01	6.59E+01	1.401	
20	2.22E-03	6.94E+01	6.73E+01	3.069	
21	2.80E-03	1.21E+02	1.12E+02	7.572	
22	2.85E-03	1.26E+02	1.17E+02	7.606	
23	3.55E-03	1.89E+02	1.87E+02	1.135	
24	4.43E-03	1.86E+02	2.22E+02	-16.398	
25	5.64E-03	1.44E+02	1.86E+02	-22.567	
26	7.13E-03	1.27E+02	1.40E+02	-8.902	
27	8.81E-03	9.99E+01	1.06E+02	-5.901	
28	1.10E-02	8.83E+01	7.98E+01	10.627	
29	1.41E-02	7.95E+01	5.72E+01	38.910	

R: 155. X: 0. Y: 155. DL: 310. REQ: 172. CF: 1.0000
CLHZ ARRAY, 29 DATA POINTS, RAMP: 155.0 MICROSEC, DATA: NSL1S4
1608 NS 900WZ OPR XTL L 6 8 -100
Ch.21 = 0.15 Ch.22 = 0.89 Ch.23 = 13 Ch.24 = 96
RMS LOG ERROR: 6.33E-02, ANTILOG YIELDS 15.6801 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.00						
P 2	0.00	0.53					
P 3	0.00	0.00	0.00				
P 4	0.00	-0.02	0.00	0.06			
T 1	0.00	0.08	0.00	-0.04	0.12		
T 2	0.00	-0.41	0.00	0.06	-0.03	0.51	
T 3	0.00	-0.09	0.00	-0.14	0.08	0.08	0.66
	P 1	P 2	P 3	P 4	T 1	T 2	T 3


NSL1S4R
MODEL:
1354.
OHM-M
508. M
24.5
OHM-M
% ERROR: 9.52
CALIBRATION: 1
OFFSET: 155 M
RAMP: 155.0
Blackhawk Geosciences, Incorporated
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)

NSL1S4R

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		405.1	1329.0		
1353.99	508.2	-103.1	-338.2	0.4	0.4
24.55					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	3.55E-03	1.89E+02	2.00E+02	-5.625	
2	4.43E-03	1.86E+02	1.69E+02	9.939	
3	5.64E-03	1.44E+02	1.42E+02	1.344	
4	7.13E-03	1.27E+02	1.22E+02	4.517	
5	8.81E-03	9.99E+01	1.07E+02	-6.329	
6	1.10E-02	8.83E+01	9.39E+01	-6.042	
7	1.41E-02	7.95E+01	8.20E+01	-3.022	
8	1.80E-02	7.86E+01	7.28E+01	7.961	

R: 155. X: 0. Y: 155. DL: 310. REQ: 172. CF: 1.0000
CLHZ ARRAY, 8 DATA POINTS, RAMP: 155.0 MICROSEC, DATA: NSL1S4R
1608 NS 900WZ OPR XTL H 3 8 -100
Ch.21 = 0.15 Ch.22 = 0.089 Ch.23 = 13 Ch.24 = 9
RMS LOG ERROR: 3.95E-02, ANTILOG YIELDS 9.5246 %
LATE TIME PARAMETERS

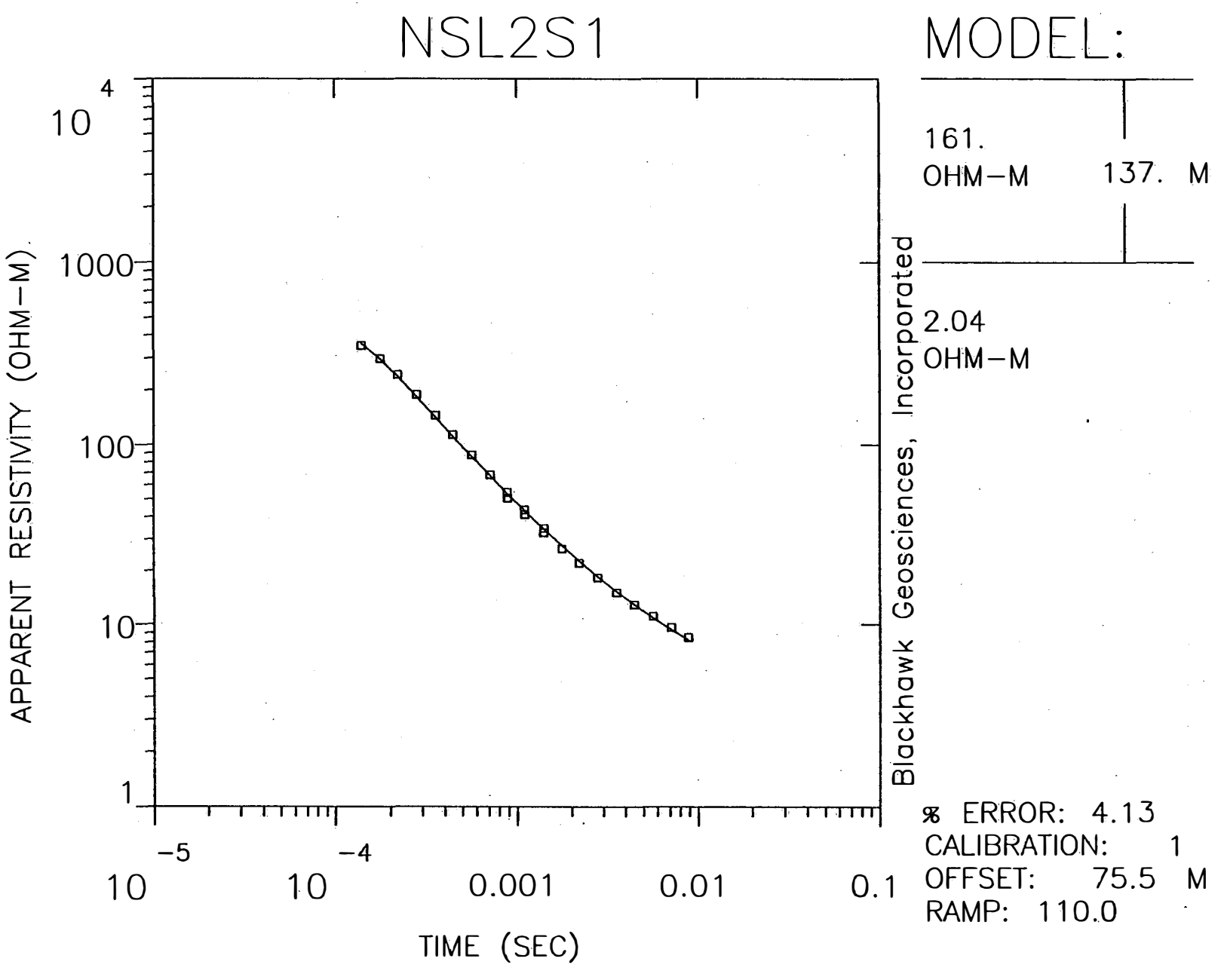
* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.12		
P 2	-0.02	1.00	
T 1	0.04	0.00	1.00
	P 1	P 2	T 1

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	330.612	1353.992	7152.583
	2	22.683	24.550	26.990
THICK	1	469.091	508.154	543.218
DEPTH	1	469.091	508.154	543.218


NSL2S1
MODEL:
161.
OHM-M
137. M
2.04
OHM-M
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
Blackhawk Geosciences, Incorporated
% ERROR: 4.13
CALIBRATION: 1
OFFSET: 75.5 M
RAMP: 110.0

NSL2S1

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		118.0	387.0		
161.20	136.7	-18.7	-61.5	0.8	0.8
2.04					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	1.40E-04	3.51E+02	3.59E+02	-2.418	
2	1.77E-04	2.97E+02	2.94E+02	0.877	
3	2.20E-04	2.42E+02	2.37E+02	2.146	
4	2.80E-04	1.89E+02	1.83E+02	2.957	
5	3.55E-04	1.44E+02	1.41E+02	2.059	
6	4.43E-04	1.13E+02	1.11E+02	2.280	
7	5.64E-04	8.72E+01	8.55E+01	2.030	
8	7.13E-04	6.80E+01	6.67E+01	1.997	
9	8.81E-04	5.44E+01	5.36E+01	1.461	
10	8.90E-04	5.07E+01	5.31E+01	-4.456	
11	1.10E-03	4.37E+01	4.31E+01	1.422	
12	1.10E-03	4.10E+01	4.30E+01	-4.505	
13	1.40E-03	3.25E+01	3.40E+01	-4.426	
14	1.41E-03	3.44E+01	3.38E+01	1.794	
15	1.77E-03	2.63E+01	2.74E+01	-3.887	
16	2.20E-03	2.19E+01	2.26E+01	-3.009	
17	2.80E-03	1.81E+01	1.84E+01	-1.791	
18	3.55E-03	1.50E+01	1.52E+01	-1.600	
19	4.43E-03	1.29E+01	1.29E+01	-0.097	
20	5.64E-03	1.11E+01	1.09E+01	1.691	
21	7.13E-03	9.61E+00	9.33E+00	3.013	
22	8.81E-03	8.47E+00	8.20E+00	3.382	

R: 75. X: 0. Y: 76. DL: 151. REQ: 84. CF: 1.0000
CLHZ ARRAY, 22 DATA POINTS, RAMP: 110.0 MICROSEC, DATA: NSL2S1
1408 NS 400WZ OPR XTL L 5 8 -100
Ch.21 = 0.11 Ch.22 = 0.89 Ch.23 = 18.5 Ch.24 =
RMS LOG ERROR: 1.76E-02, ANTILOG YIELDS 4.1326 %
LATE TIME PARAMETERS

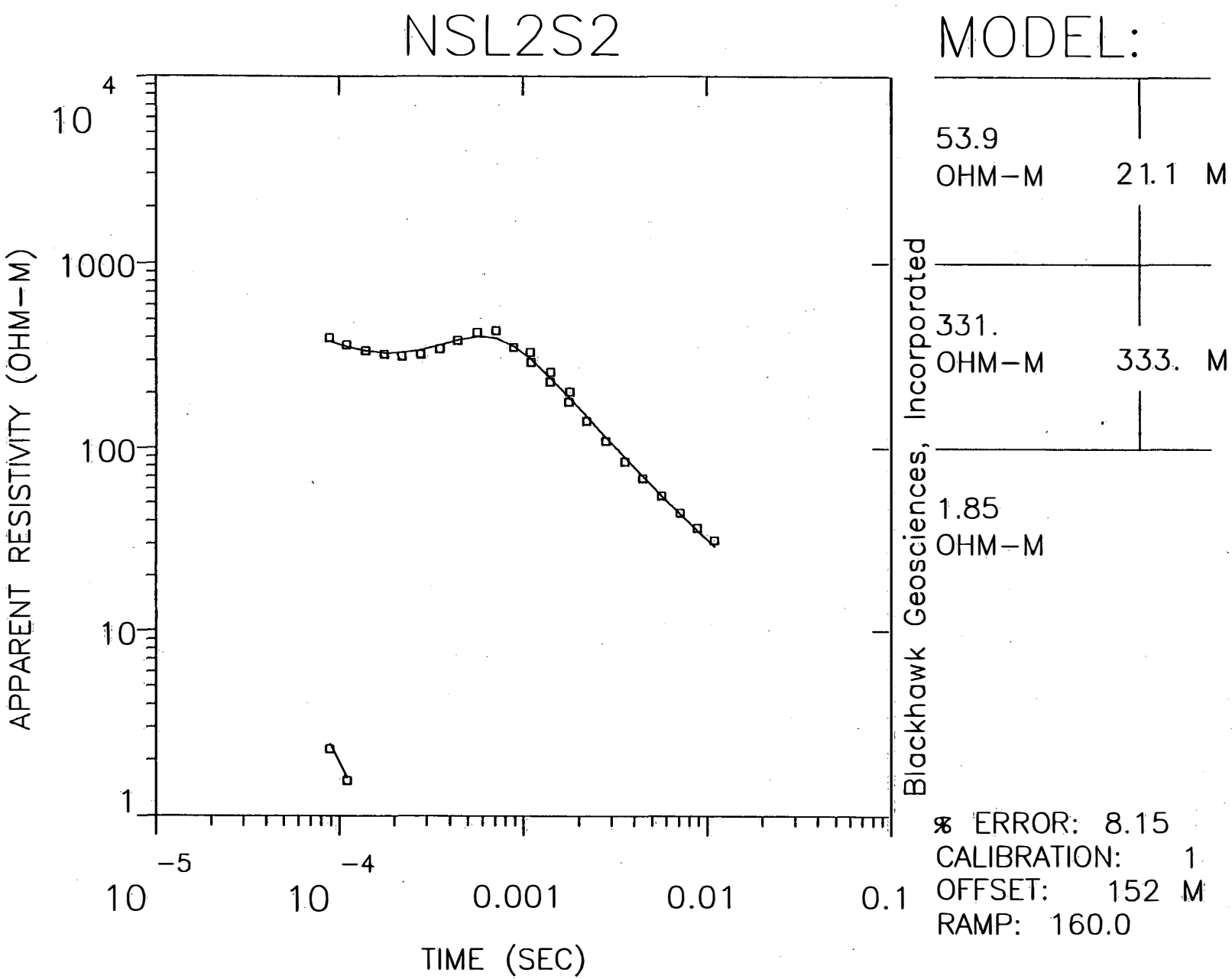
* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

	P 1	P 2	T 1
P 1	0.94		
P 2	-0.03	0.95	
T 1	0.00	0.00	1.00

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

LAYER		MINIMUM	BEST	MAXIMUM
RHO	1	144.736	161.200	189.572
	2	1.811	2.037	2.276
THICK	1	134.772	136.694	138.557
DEPTH	1	134.772	136.694	138.557


NSL2S2
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
53.9
OHM-M
21.1 M
331.
OHM-M
333. M
1.85
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 8.15
CALIBRATION: 1
OFFSET: 152 M
RAMP: 160.0

NSL2S2

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		324.9	1066.0		
53.87	21.1	303.9	996.9	0.4	0.4
330.80	333.0	-29.2	-95.7	1.0	1.4
1.85					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	3.97E+02	3.80E+02	4.410	
2	1.10E-04	3.63E+02	3.55E+02	2.215	
3	1.40E-04	3.38E+02	3.37E+02	0.529	
4	1.77E-04	3.23E+02	3.29E+02	-1.944	
5	2.20E-04	3.16E+02	3.30E+02	-4.429	
6	2.80E-04	3.24E+02	3.42E+02	-5.229	
7	3.55E-04	3.46E+02	3.62E+02	-4.405	
8	4.43E-04	3.85E+02	3.84E+02	0.150	
9	5.64E-04	4.25E+02	4.02E+02	5.663	
10	7.13E-04	4.35E+02	3.95E+02	10.119	
11	8.90E-04	3.52E+02	3.58E+02	-1.809	
12	1.10E-03	3.31E+02	3.06E+02	8.266	
13	1.10E-03	2.92E+02	3.05E+02	-4.246	
14	1.40E-03	2.29E+02	2.42E+02	-5.385	
15	1.41E-03	2.59E+02	2.40E+02	7.619	
16	1.77E-03	1.78E+02	1.89E+02	-5.878	
17	1.80E-03	2.02E+02	1.86E+02	8.667	
18	2.20E-03	1.40E+02	1.49E+02	-6.310	
19	2.80E-03	1.09E+02	1.15E+02	-4.928	
20	3.55E-03	8.43E+01	8.92E+01	-5.502	
21	4.43E-03	6.82E+01	7.06E+01	-3.418	
22	5.64E-03	5.49E+01	5.51E+01	-0.282	
23	7.13E-03	4.42E+01	4.36E+01	1.480	
24	8.81E-03	3.66E+01	3.55E+01	3.023	
25	1.10E-02	3.13E+01	2.89E+01	8.269	

R: 152. X: 0. Y: 152. DL: 304. REQ: 169. CF: 1.0000
CLHZ ARRAY, 25 DATA POINTS, RAMP: 160.0 MICROSEC, DATA: NSL2S2
1408 NS 500WZ OPR XTL L 6 8 -100
Ch.21 = 0.165 Ch.22 = 0.89 Ch.23 = 14.5 Ch.24 =
RMS LOG ERROR: 3.40E-02, ANTILOG YIELDS 8.1524 %
LATE TIME PARAMETERS

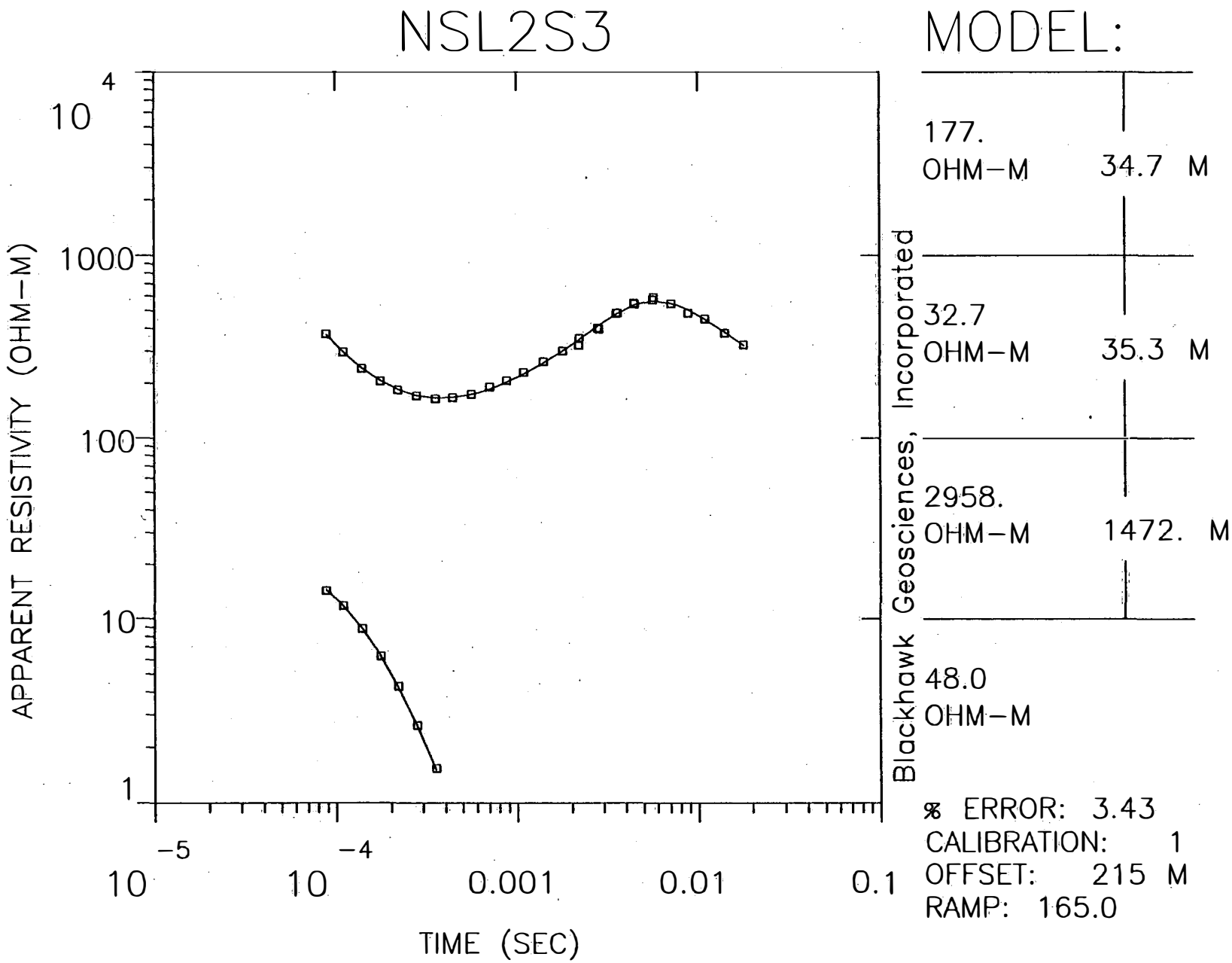
* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER
P 1 0.43
P 2 0.24 0.34
P 3 -0.01 -0.08 0.11

```
T 1 -0.35 -0.23  0.01  0.30
T 2  0.02  0.02 -0.05  0.05  0.97
       P 1   P 2   P 3   T 1   T 2
```

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	38.500	53.872	75.294
	2	265.339	330.799	452.795
	3	1.140	1.847	2.994
THICK	1	10.749	21.056	36.847
	2	320.224	333.041	349.122
DEPTH	1	10.749	21.056	36.847
	2	344.577	354.097	364.049


NSL2S3
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
177.
OHM-M
34.7 M
32.7
OHM-M
35.3 M
2958.
OHM-M
1472. M
48.0
OHM-M
% ERROR: 3.43
CALIBRATION: 1
OFFSET: 215 M
RAMP: 165.0
Blackhawk Geosciences, Incorporated

NSL2S3

MODEL: 4 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		555.0	1821.0		
177.48	34.7	520.3	1707.0	0.2	0.2
32.73	35.3	485.0	1591.1	1.1	1.3
2957.67	1471.7	-986.7	-3237.2	0.5	1.8
48.02					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	3.72E+02	3.69E+02	0.825	
2	1.10E-04	2.97E+02	2.97E+02	-0.077	
3	1.40E-04	2.41E+02	2.41E+02	-0.291	
4	1.77E-04	2.05E+02	2.06E+02	-0.601	
5	2.20E-04	1.83E+02	1.85E+02	-0.970	
6	2.80E-04	1.71E+02	1.72E+02	-0.653	
7	3.55E-04	1.64E+02	1.66E+02	-1.323	
8	4.43E-04	1.66E+02	1.67E+02	-0.456	
9	5.64E-04	1.74E+02	1.73E+02	0.205	
10	7.13E-04	1.90E+02	1.86E+02	2.459	
11	8.81E-04	2.07E+02	2.02E+02	2.493	
12	1.10E-03	2.30E+02	2.24E+02	2.445	
13	1.41E-03	2.62E+02	2.58E+02	1.604	
14	1.80E-03	3.00E+02	3.01E+02	-0.121	
15	2.20E-03	3.24E+02	3.46E+02	-6.324	
16	2.22E-03	3.53E+02	3.48E+02	1.432	
17	2.80E-03	4.00E+02	4.09E+02	-2.079	
18	2.85E-03	3.96E+02	4.14E+02	-4.398	
19	3.55E-03	4.83E+02	4.77E+02	1.111	
20	3.60E-03	4.84E+02	4.82E+02	0.558	
21	4.43E-03	5.48E+02	5.34E+02	2.619	
22	4.49E-03	5.43E+02	5.37E+02	0.977	
23	5.64E-03	5.72E+02	5.64E+02	1.310	
24	5.70E-03	5.91E+02	5.65E+02	4.626	
25	7.13E-03	5.44E+02	5.48E+02	-0.694	
26	8.81E-03	4.85E+02	5.06E+02	-4.281	
27	1.10E-02	4.50E+02	4.46E+02	0.702	
28	1.41E-02	3.78E+02	3.80E+02	-0.452	
29	1.80E-02	3.26E+02	3.23E+02	0.921	

R: 215. X: 0. Y: 215. DL: 430. REQ: 239. CF: 1.0000
CLHZ ARRAY, 29 DATA POINTS, RAMP: 165.0 MICROSEC, DATA: NSL2S3
1408 NS 600WZ OPR XTL L 5 8 -1000
Ch.21 = 0.165 Ch.22 = 0.89 Ch.23 = 11.5 Ch.24 =
RMS LOG ERROR: 1.47E-02, ANTILOG YIELDS 3.4312 %
LATE TIME PARAMETERS

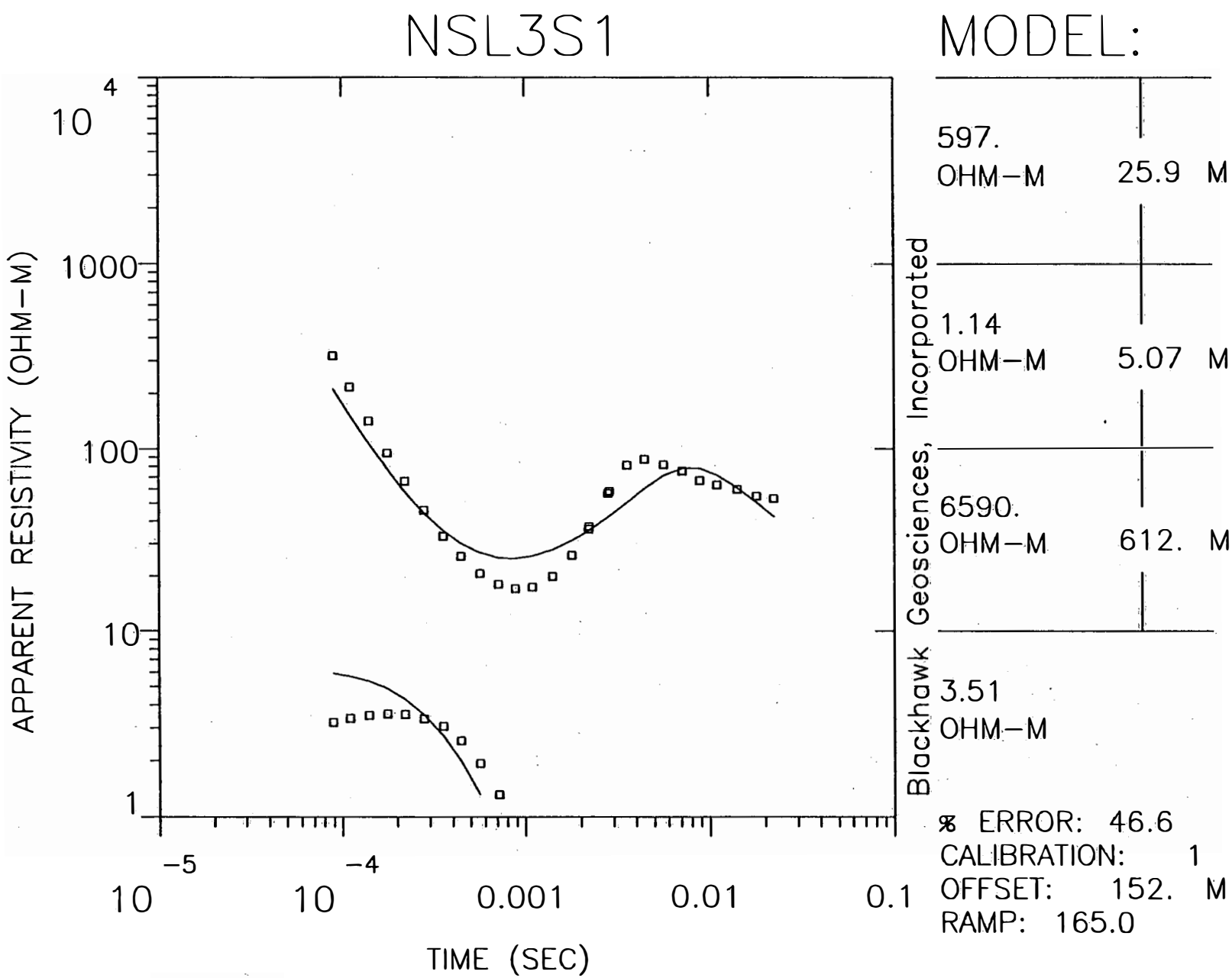
* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.12						
P 2	0.13	0.71					
P 3	0.05	-0.11	0.29				
P 4	-0.05	0.10	-0.15	0.48			
T 1	0.18	0.19	-0.04	-0.07	0.68		
T 2	-0.06	-0.32	-0.16	0.11	0.27	0.61	
T 3	0.00	-0.01	0.03	0.04	0.01	-0.01	0.99
	P 1	P 2	P 3	P 4	T 1	T 2	T 3

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	131.632	177.479	238.888
	2	25.542	32.727	49.197
	3	2109.036	2957.667	4412.429
	4	30.963	48.018	69.035
THICK	1	24.629	34.742	42.321
	2	27.068	35.334	58.340
	3	1419.868	1471.662	1531.644
DEPTH	1	24.629	34.742	42.321
	2	66.917	70.076	82.969
	3	1490.213	1541.738	1601.703


NSL3S1
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
597.
OHM-M
25.9 M
1.14
OHM-M
5.07 M
6590.
OHM-M
612. M
3.51
OHM-M
% ERROR: 46.6
CALIBRATION: 1
OFFSET: 152. M
RAMP: 165.0
Blackhawk Geosciences, Incorporated

NSL3S1

MODEL: 4 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		366.1	1201.0		
596.50	25.9	340.2	1116.1	0.0	0.0
1.14	5.1	335.1	1099.5	4.4	4.5
6589.51	612.5	-277.3	-909.9	0.1	4.6
3.51					

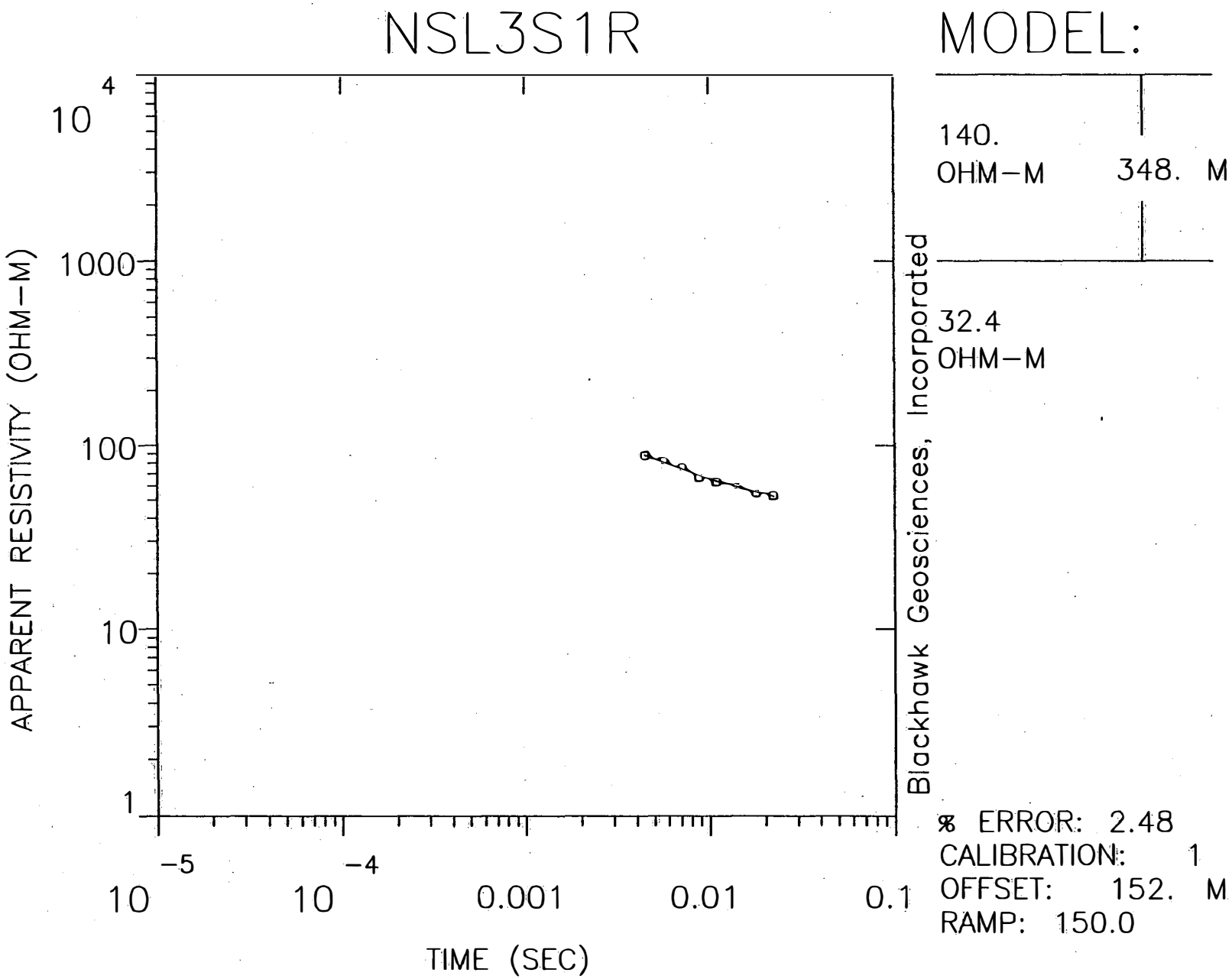
	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	3.19E+02	2.13E+02	49.860	
2	1.10E-04	2.17E+02	1.53E+02	41.560	
3	1.40E-04	1.42E+02	1.07E+02	32.483	
4	1.77E-04	9.47E+01	7.70E+01	22.899	
5	2.20E-04	6.61E+01	5.83E+01	13.483	
6	2.80E-04	4.59E+01	4.43E+01	3.524	
7	3.55E-04	3.29E+01	3.54E+01	-7.195	
8	4.43E-04	2.56E+01	3.01E+01	-15.213	
9	5.64E-04	2.06E+01	2.67E+01	-22.793	
10	7.13E-04	1.81E+01	2.51E+01	-28.026	
11	8.81E-04	1.70E+01	2.48E+01	-31.490	
12	1.10E-03	1.74E+01	2.56E+01	-32.206	
13	1.41E-03	1.99E+01	2.78E+01	-28.517	
14	1.80E-03	2.59E+01	3.12E+01	-16.990	
15	2.20E-03	3.62E+01	3.53E+01	2.409	
16	2.22E-03	3.72E+01	3.56E+01	4.564	
17	2.80E-03	5.69E+01	4.19E+01	35.820	
18	2.85E-03	5.81E+01	4.25E+01	36.799	
19	3.55E-03	8.11E+01	5.05E+01	60.688	
20	4.43E-03	8.76E+01	6.03E+01	45.400	
21	5.64E-03	8.17E+01	7.12E+01	14.756	
22	7.13E-03	7.53E+01	7.82E+01	-3.762	
23	8.81E-03	6.66E+01	7.81E+01	-14.792	
24	1.10E-02	6.30E+01	7.18E+01	-12.228	
25	1.41E-02	5.99E+01	6.07E+01	-1.402	
26	1.80E-02	5.49E+01	5.03E+01	9.065	
27	2.22E-02	5.32E+01	4.23E+01	25.694	

R: 152. X: 0. Y: 153. DL: 305. REQ: 170. CF: 1.0000
CLHZ ARRAY, 27 DATA POINTS, RAMP: 165.0 MICROSEC, DATA: NSL3S1
1508 NS 700WZ OPR XTL H 2 8 -100
Ch.21 = 0.15 Ch.22 = 0.089 Ch.23 = 14.5 Ch.24 =
RMS LOG ERROR: 1.66E-01, ANTILOG YIELDS 46.5878 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.01						
P 2	0.00	0.78					
P 3	0.01	-0.02	0.01				
P 4	0.01	0.22	-0.01	0.31			
T 1	0.02	0.09	0.00	-0.07	0.95		
T 2	-0.01	-0.22	-0.03	0.23	0.09	0.77	
T 3	0.00	0.00	0.00	-0.02	0.00	0.00	1.00
	P 1	P 2	P 3	P 4	T 1	T 2	T 3


NSL3S1R
MODEL:
140.
OHM-M
348. M
32.4
OHM-M
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
Blackhawk Geosciences, Incorporated
% ERROR: 2.48
CALIBRATION: 1
OFFSET: 152. M
RAMP: 150.0

NSL3S1R

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		366.1	1201.0		
139.63	347.6	18.5	60.7	2.5	2.5
32.42					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	4.43E-03	8.76E+01	8.85E+01	-0.965	
2	5.64E-03	8.17E+01	8.03E+01	1.745	
3	7.13E-03	7.53E+01	7.36E+01	2.270	
4	8.81E-03	6.66E+01	6.84E+01	-2.698	
5	1.10E-02	6.30E+01	6.38E+01	-1.230	
6	1.41E-02	5.99E+01	5.92E+01	1.169	
7	1.80E-02	5.49E+01	5.55E+01	-1.141	
8	2.22E-02	5.32E+01	5.27E+01	0.876	

R: 152. X: 0. Y: 153. DL: 305. REQ: 170. CF: 1.0000
CLHZ ARRAY, 8 DATA POINTS, RAMP: 150.0 MICROSEC, DATA: NSL3S1R
1508 NS 700WZ OPR XTL H 2 8 -100
Ch.21 = 0.15 Ch.22 = 0.089 Ch.23 = 14.5 Ch.24 =
RMS LOG ERROR: 1.07E-02, ANTILOG YIELDS 2.4841 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

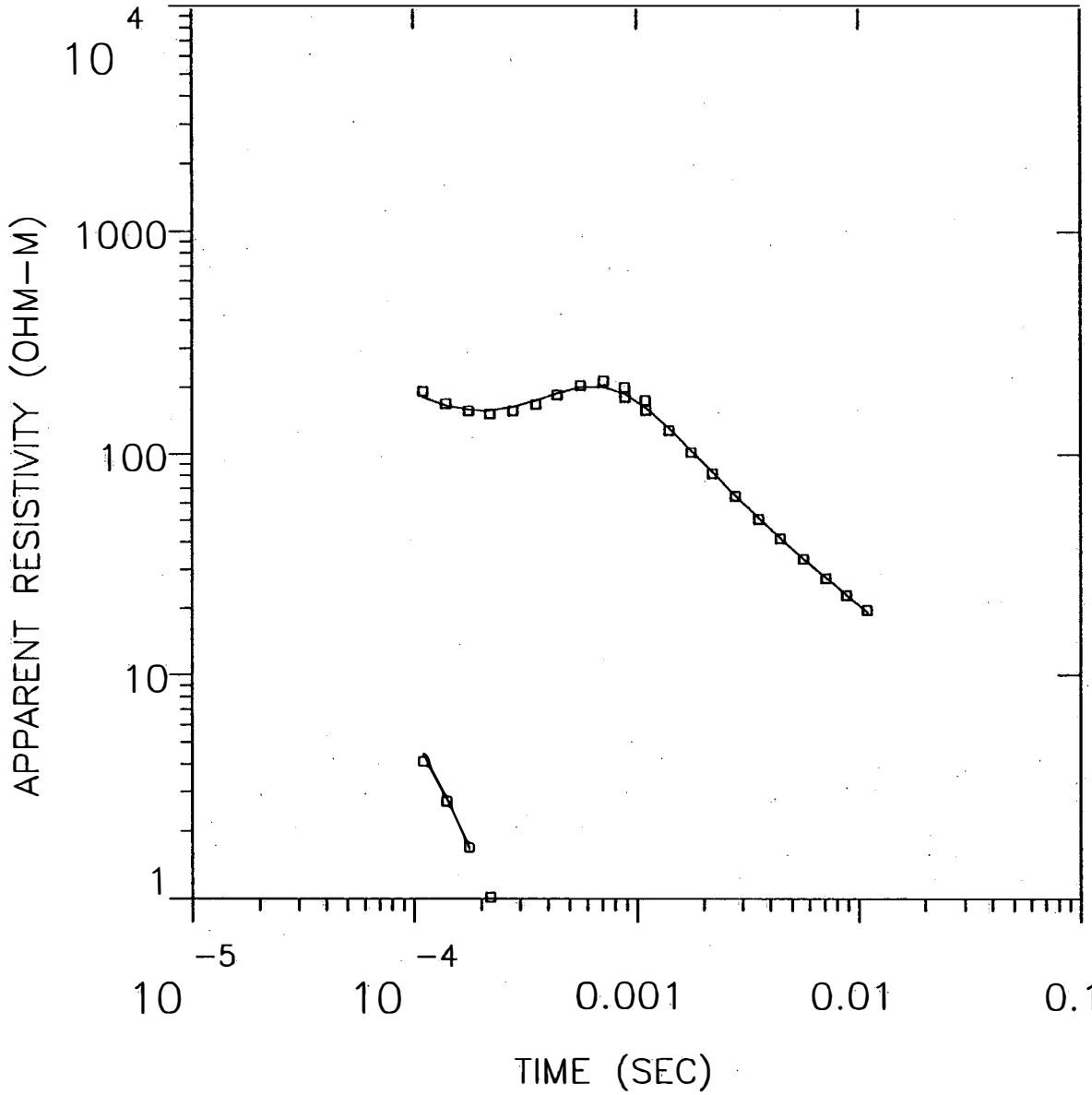
PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.96		
P 2	-0.01	1.00	
T 1	0.02	0.00	0.99
	P 1	P 2	T 1

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	103.601	139.626	175.638
	2	30.517	32.422	33.967
THICK	1	306.952	347.559	408.512
DEPTH	1	306.952	347.559	408.512

NSL3S2



MODEL:

34.2
OHM-M

34.7 M

1023.
OHM-M

236. M

2.45
OHM-M

Blackhawk Geosciences, Incorporated

% ERROR: 5.20
CALIBRATION: 1
OFFSET: 152. M
RAMP: 165.0

NSL3S2

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		245.1	804.0		
34.17	34.7	210.3	690.0	1.0	1.0
1023.38	236.3	-26.0	-85.4	0.2	1.2
2.45					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	1.10E-04	1.92E+02	1.81E+02	5.723	
2	1.40E-04	1.69E+02	1.65E+02	2.318	
3	1.77E-04	1.56E+02	1.58E+02	-0.965	
4	2.20E-04	1.52E+02	1.57E+02	-3.267	
5	2.80E-04	1.57E+02	1.63E+02	-3.895	
6	3.55E-04	1.68E+02	1.74E+02	-3.820	
7	4.43E-04	1.85E+02	1.88E+02	-1.231	
8	5.64E-04	2.04E+02	2.00E+02	1.967	
9	7.13E-04	2.14E+02	2.01E+02	6.350	
10	8.81E-04	2.00E+02	1.87E+02	6.927	
11	8.90E-04	1.80E+02	1.86E+02	-3.183	
12	1.10E-03	1.75E+02	1.62E+02	7.703	
13	1.10E-03	1.58E+02	1.62E+02	-2.282	
14	1.40E-03	1.28E+02	1.31E+02	-2.318	
15	1.77E-03	1.02E+02	1.04E+02	-1.953	
16	2.20E-03	8.16E+01	8.32E+01	-1.966	
17	2.80E-03	6.45E+01	6.54E+01	-1.246	
18	3.55E-03	5.09E+01	5.18E+01	-1.815	
19	4.43E-03	4.14E+01	4.20E+01	-1.323	
20	5.64E-03	3.35E+01	3.36E+01	-0.584	
21	7.13E-03	2.74E+01	2.74E+01	0.096	
22	8.81E-03	2.29E+01	2.29E+01	-0.014	
23	1.10E-02	1.96E+01	1.93E+01	1.974	

R: 152. X: 0. Y: 153. DL: 305. REQ: 170. CF: 1.0000
CLHZ ARRAY, 23 DATA POINTS, RAMP: 165.0 MICROSEC, DATA: NSL3S2
1508 NS 800WZ OPR XTL H 3 8 -100
Ch.21 = 0.16 Ch.22 = 0.089 Ch.23 = 14 Ch.24 = 9
RMS LOG ERROR: 2.20E-02, ANTILOG YIELDS 5.1960 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

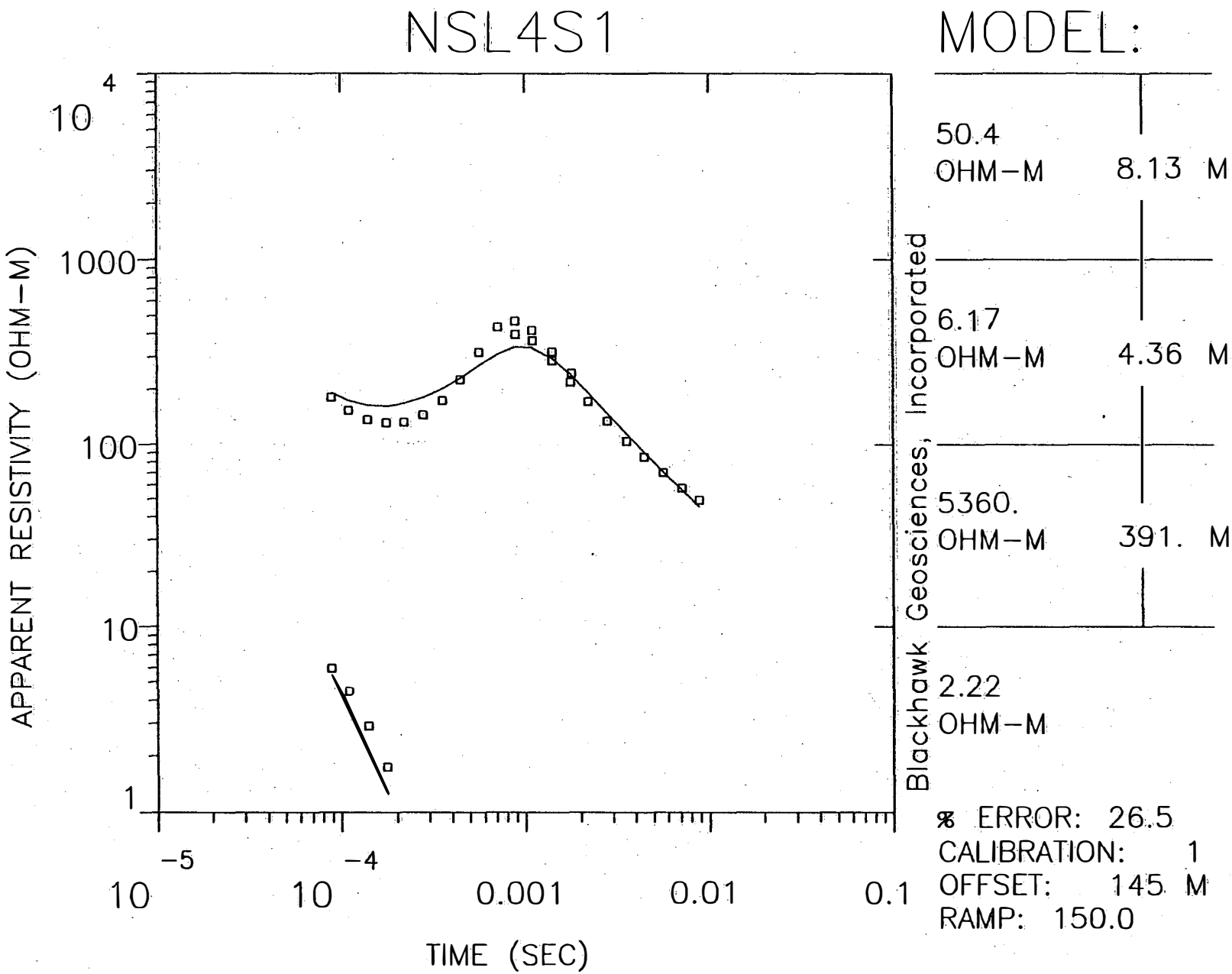
PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.60				
P 2	0.02	0.00			
P 3	0.01	-0.01	0.14		
T 1	-0.43	-0.03	0.06	0.44	
T 2	0.05	0.01	-0.02	0.06	0.95

P 1 P 2 P 3 T 1 T 2

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	26.372	34.171	42.819
	2	524.159	1023.384	3236.225
	3	1.831	2.451	2.960
THICK	1	26.304	34.740	46.740
	2	229.192	236.341	244.147
DEPTH	1	26.304	34.740	46.740
	2	266.742	271.082	275.932



MODEL:

50.4 OHM-M — 8.13 M

6.17 OHM-M — 4.36 M

5360. OHM-M — 391. M

2.22 OHM-M

% ERROR: 26.5
CALIBRATION: 1
OFFSET: 145 M
RAMP: 150.0

NSL4S1

MODEL: 4 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		339.9	1115.0		
50.43	8.1	331.7	1088.3	0.2	0.2
6.17	4.4	327.4	1074.0	0.7	0.9
5359.69	390.7	-63.3	-207.8	0.1	0.9
2.22					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	1.80E+02	1.91E+02	-5.553	
2	1.10E-04	1.53E+02	1.73E+02	-11.457	
3	1.40E-04	1.36E+02	1.63E+02	-16.278	
4	1.77E-04	1.30E+02	1.61E+02	-19.711	
5	2.20E-04	1.31E+02	1.67E+02	-21.403	
6	2.80E-04	1.45E+02	1.80E+02	-19.484	
7	3.55E-04	1.73E+02	2.01E+02	-13.704	
8	4.43E-04	2.25E+02	2.29E+02	-1.706	
9	5.64E-04	3.18E+02	2.69E+02	17.994	
10	7.13E-04	4.35E+02	3.11E+02	39.673	
11	8.81E-04	4.69E+02	3.38E+02	38.636	
12	8.90E-04	3.96E+02	3.39E+02	16.957	
13	1.10E-03	4.15E+02	3.36E+02	23.557	
14	1.10E-03	3.66E+02	3.35E+02	9.234	
15	1.40E-03	2.87E+02	2.95E+02	-2.679	
16	1.41E-03	3.20E+02	2.93E+02	9.100	
17	1.77E-03	2.18E+02	2.40E+02	-8.885	
18	1.80E-03	2.44E+02	2.36E+02	3.203	
19	2.20E-03	1.71E+02	1.92E+02	-10.912	
20	2.80E-03	1.33E+02	1.48E+02	-9.950	
21	3.55E-03	1.04E+02	1.15E+02	-9.669	
22	4.43E-03	8.54E+01	9.08E+01	-5.910	
23	5.64E-03	6.98E+01	7.07E+01	-1.243	
24	7.13E-03	5.76E+01	5.59E+01	3.136	
25	8.81E-03	4.94E+01	4.54E+01	8.609	

R: 145. X: 0. Y: 145. DL: 290. REQ: 161. CF: 1.0000
CLHZ ARRAY, 25 DATA POINTS, RAMP: 150.0 MICROSEC, DATA: NSL4S1
1708 NS 1000WZ OPR XTL L 6 8 -100
Ch.21 = 0.15 Ch.22 = 0.89 Ch.23 = 14 Ch.24 = 84
RMS LOG ERROR: 1.02E-01, ANTILOG YIELDS 26.4503 %
LATE TIME PARAMETERS

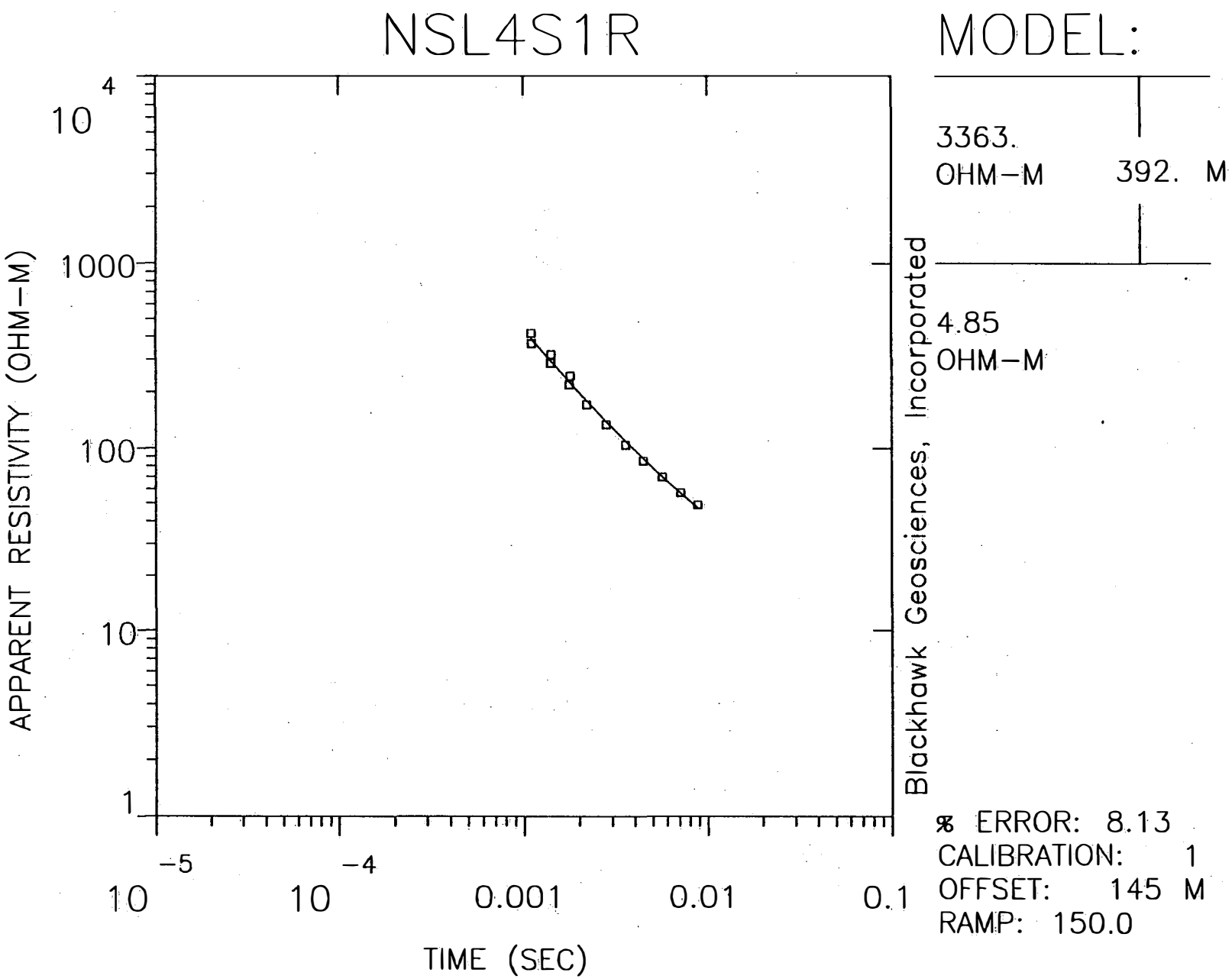
* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER
P 1 0.02
P 2 0.11 0.47

P 3	0.00	0.01	0.00				
P 4	0.00	0.00	0.00	0.05			
T 1	-0.02	-0.08	0.00	0.01	0.02		
T 2	-0.10	-0.44	-0.01	0.03	0.10	0.47	
T 3	0.00	0.00	0.00	-0.05	0.02	-0.01	0.95
	P 1	P 2	P 3	P 4	T 1	T 2	T 3

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	23.203	50.430	140.669
	2	0.745	6.168	16.217
	3	1694.882	5359.687	53596.859
	4	0.253	2.223	5.862
THICK	1	2.393	8.128	16.579
	2	0.355	4.357	13.277
	3	345.312	390.709	423.933
DEPTH	1	2.393	8.128	16.579
	2	7.311	12.485	20.640
	3	358.322	403.194	436.262



MODEL:

3363.
OHM-M

392. M

4.85
OHM-M

% ERROR: 8.13
CALIBRATION: 1
OFFSET: 145 M
RAMP: 150.0

NSL4S1R

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		339.9	1115.0		
3362.89	392.0	-52.2	-171.1	0.1	0.1
4.85					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	1.10E-03	4.15E+02	3.90E+02	6.442	
2	1.10E-03	3.66E+02	3.88E+02	-5.600	
3	1.40E-03	2.87E+02	2.95E+02	-2.703	
4	1.41E-03	3.20E+02	2.92E+02	9.403	
5	1.77E-03	2.18E+02	2.27E+02	-3.755	
6	1.80E-03	2.44E+02	2.23E+02	9.172	
7	2.20E-03	1.71E+02	1.80E+02	-4.928	
8	2.80E-03	1.33E+02	1.39E+02	-4.185	
9	3.55E-03	1.04E+02	1.09E+02	-5.302	
10	4.43E-03	8.54E+01	8.81E+01	-3.063	
11	5.64E-03	6.98E+01	7.01E+01	-0.372	
12	7.13E-03	5.76E+01	5.70E+01	1.129	
13	8.81E-03	4.94E+01	4.74E+01	4.171	

R: 145. X: 0. Y: 145. DL: 290. REQ: 161. CF: 1.0000
CLHZ ARRAY, 13 DATA POINTS, RAMP: 150.0 MICROSEC, DATA: NSL4S1R
1708 NS 1000WZ OPR XTL L 6 8 -100
Ch.21 = 0.15 Ch.22 = 0.89 Ch.23 = 14 Ch.24 = 84
RMS LOG ERROR: 3.40E-02, ANTILOG YIELDS 8.1346 %
LATE TIME PARAMETERS

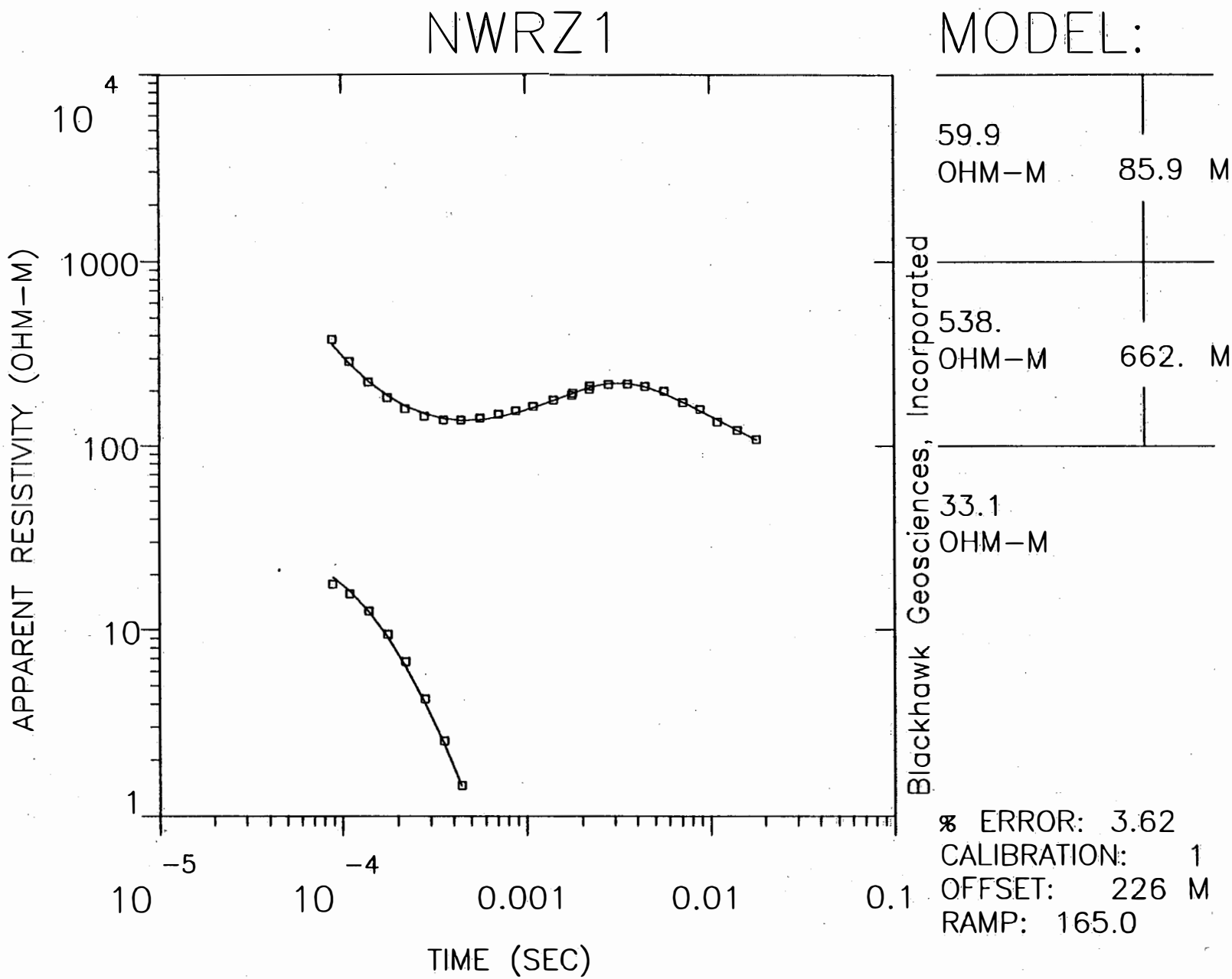
* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.06		
P 2	-0.11	0.85	
T 1	0.00	0.00	1.00
	P 1	P 2	T 1

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	1063.438	3362.888	10634.385
	2	3.719	4.849	6.321
THICK	1	384.937	392.012	399.091
DEPTH	1	384.937	392.012	399.091


NWRZ1
MODEL:
APPARENT RESISTIVITY (OHM-M)
10 4
1000
100
10
1
10 -5
10 -4
0.001
0.01
0.1
TIME (SEC)
59.9
OHM-M
85.9 M
538.
OHM-M
662. M
33.1
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 3.62
CALIBRATION: 1
OFFSET: 226 M
RAMP: 165.0

NWRZ1

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		508.1	1667.0		
59.91	85.9	422.2	1385.2	1.4	1.4
537.69	662.1	-239.9	-787.1	1.2	2.7
33.10					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	3.81E+02	3.58E+02	6.470	
2	1.10E-04	2.90E+02	2.83E+02	2.583	
3	1.40E-04	2.24E+02	2.25E+02	-0.543	
4	1.77E-04	1.84E+02	1.89E+02	-2.533	
5	2.20E-04	1.60E+02	1.66E+02	-3.732	
6	2.80E-04	1.46E+02	1.50E+02	-2.980	
7	3.55E-04	1.38E+02	1.42E+02	-2.365	
8	4.43E-04	1.38E+02	1.38E+02	-0.106	
9	5.64E-04	1.42E+02	1.39E+02	1.729	
10	7.13E-04	1.50E+02	1.44E+02	3.980	
11	8.81E-04	1.56E+02	1.51E+02	3.205	
12	1.10E-03	1.65E+02	1.62E+02	1.922	
13	1.41E-03	1.78E+02	1.78E+02	0.164	
14	1.77E-03	1.89E+02	1.94E+02	-2.316	
15	1.80E-03	1.94E+02	1.95E+02	-0.322	
16	2.20E-03	2.04E+02	2.09E+02	-2.124	
17	2.22E-03	2.12E+02	2.09E+02	1.454	
18	2.80E-03	2.17E+02	2.20E+02	-1.356	
19	3.55E-03	2.18E+02	2.21E+02	-1.093	
20	4.43E-03	2.11E+02	2.11E+02	-0.124	
21	5.64E-03	1.99E+02	1.94E+02	2.855	
22	7.13E-03	1.72E+02	1.73E+02	-0.480	
23	8.81E-03	1.58E+02	1.55E+02	1.745	
24	1.10E-02	1.35E+02	1.39E+02	-2.429	
25	1.41E-02	1.22E+02	1.22E+02	-0.016	
26	1.80E-02	1.08E+02	1.08E+02	-0.035	

R: 226. X: 0. Y: 226. DL: 452. REQ: 251. CF: 1.0000
CLHZ ARRAY, 26 DATA POINTS, RAMP: 165.0 MICROSEC, DATA: NWRZ1
1708 WR 100WZ OPR XTL L 7 8 -100
Ch.21 = 0.165 Ch.22 = 0.89 Ch.23 = 11 Ch.24 = 2
RMS LOG ERROR: 1.55E-02, ANTILOG YIELDS 3.6233 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

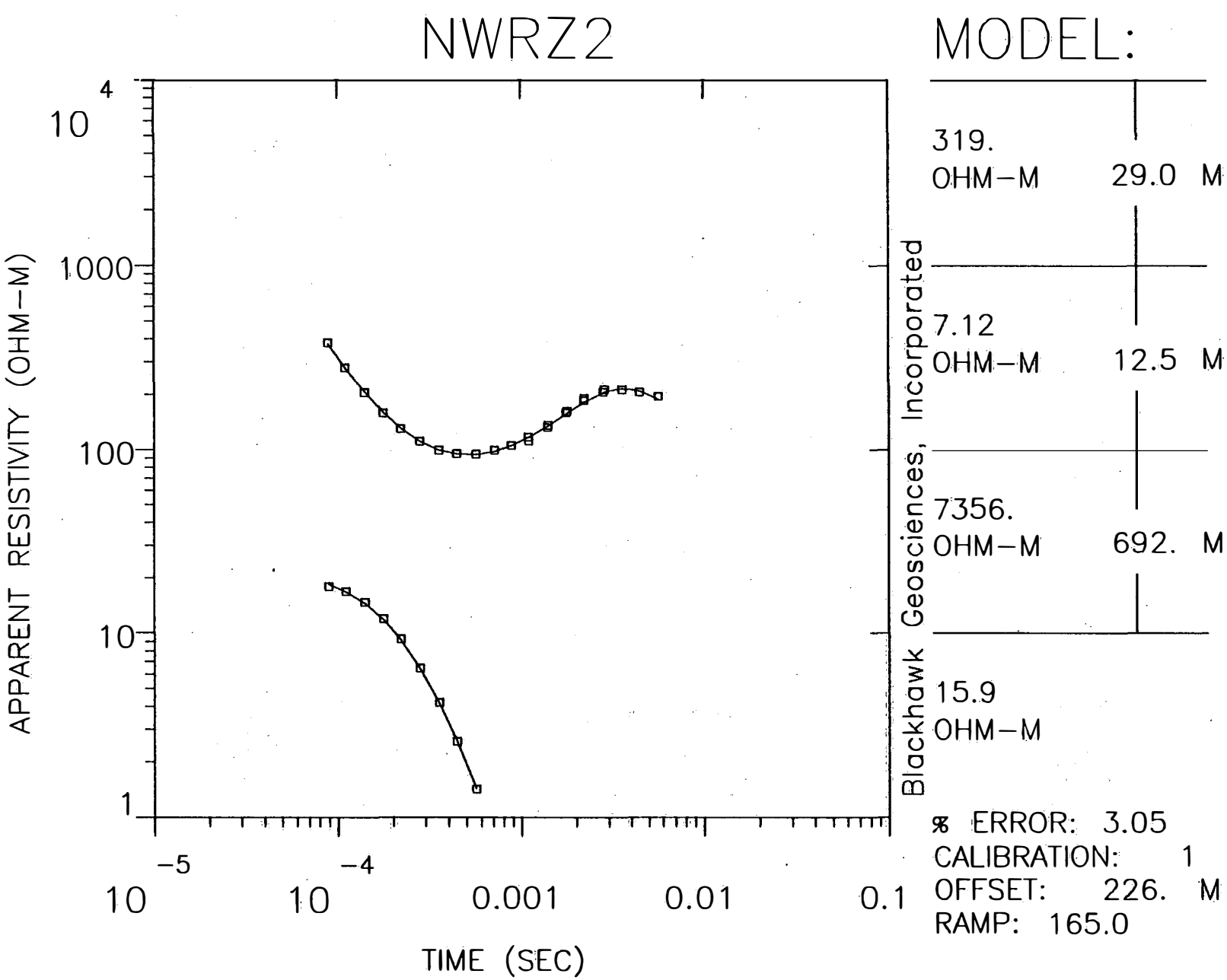
PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.98				
P 2	-0.05	0.61			
P 3	0.00	-0.09	0.83		
T 1	-0.04	-0.16	-0.02	0.91	
T 2	0.01	0.06	0.04	0.02	0.98

P 1 P 2 P 3 T 1 T 2

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	54.385	59.914	66.005
	2	416.190	537.686	747.472
	3	25.163	33.096	40.671
THICK	1	71.614	85.907	103.054
	2	604.417	662.106	710.739
DEPTH	1	71.614	85.907	103.054
	2	701.465	748.013	791.362


NWRZ2
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
319.
OHM-M
29.0 M
7.12
OHM-M
12.5 M
7356.
OHM-M
692. M
15.9
OHM-M
% ERROR: 3.05
CALIBRATION: 1
OFFSET: 226. M
RAMP: 165.0
Blackhawk Geosciences, Incorporated

NWRZ2

MODEL: 4 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		506.9	1663.0		
319.41	29.0	477.8	1567.7	0.1	0.1
7.12	12.5	465.4	1526.8	1.8	1.8
7355.66	691.8	-226.4	-742.8	0.1	1.9
15.93					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	3.82E+02	3.75E+02	1.995	
2	1.10E-04	2.80E+02	2.80E+02	-0.100	
3	1.40E-04	2.05E+02	2.07E+02	-0.898	
4	1.77E-04	1.58E+02	1.60E+02	-1.128	
5	2.20E-04	1.30E+02	1.31E+02	-0.828	
6	2.80E-04	1.11E+02	1.11E+02	0.055	
7	3.55E-04	9.95E+01	9.97E+01	-0.216	
8	4.43E-04	9.51E+01	9.47E+01	0.474	
9	5.64E-04	9.47E+01	9.42E+01	0.493	
10	7.13E-04	9.95E+01	9.82E+01	1.379	
11	8.81E-04	1.06E+02	1.05E+02	0.525	
12	1.10E-03	1.17E+02	1.17E+02	0.188	
13	1.10E-03	1.12E+02	1.17E+02	-4.539	
14	1.40E-03	1.32E+02	1.35E+02	-1.933	
15	1.41E-03	1.36E+02	1.36E+02	0.253	
16	1.77E-03	1.59E+02	1.58E+02	1.109	
17	1.80E-03	1.63E+02	1.59E+02	2.269	
18	2.20E-03	1.86E+02	1.81E+02	2.320	
19	2.22E-03	1.91E+02	1.83E+02	4.596	
20	2.80E-03	2.07E+02	2.05E+02	0.746	
21	2.85E-03	2.13E+02	2.07E+02	3.335	
22	3.55E-03	2.12E+02	2.16E+02	-1.907	
23	4.43E-03	2.06E+02	2.10E+02	-1.861	
24	5.64E-03	1.95E+02	1.89E+02	3.398	

R: 226. X: 0. Y: 227. DL: 453. REQ: 252. CF: 1.0000
CLHZ ARRAY, 24 DATA POINTS, RAMP: 165.0 MICROSEC, DATA: NWRZ2
1808 WR 200WZ OPR XTL L 6 8 -100 2
Ch.21 = 0.165 Ch.22 = 0.89 Ch.23 = 11 Ch.24 = 2
RMS LOG ERROR: 1.30E-02, ANTILOG YIELDS 3.0500 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

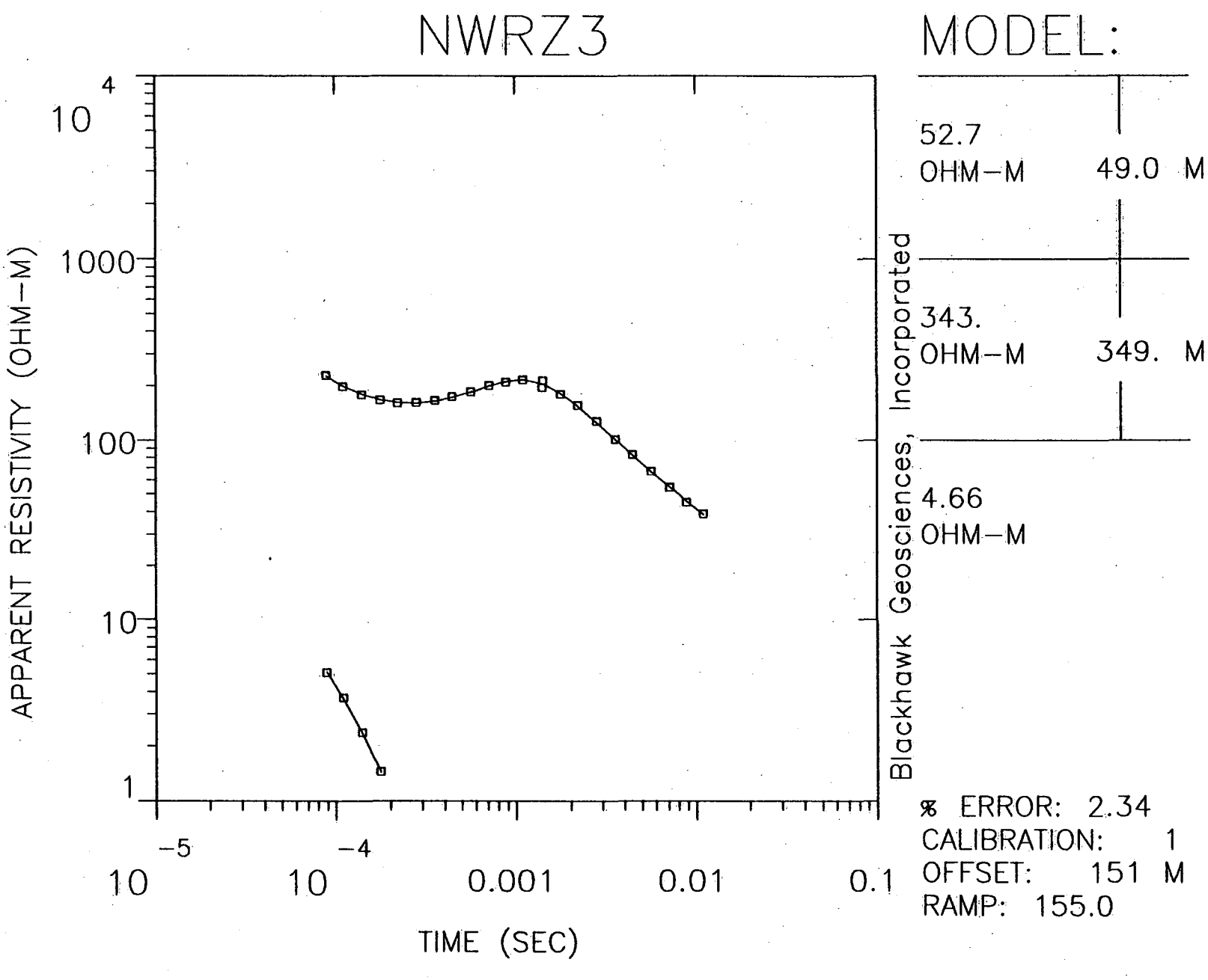
PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.15					
P 2	-0.02	0.84				
P 3	0.12	-0.07	0.12			
P 4	0.00	0.27	-0.06	0.41		
T 1	0.09	0.09	0.02	-0.14	0.94	
T 2	-0.07	-0.17	-0.07	0.28	0.10	0.81

```
T 3 -0.01 -0.02  0.00  0.02  0.01 -0.02  1.00
       P 1   P 2   P 3   P 4   T 1   T 2   T 3
```

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	171.237	319.410	435.258
	2	6.217	7.122	8.740
	3	3988.250	7355.663	13566.294
	4	10.337	15.934	20.859
THICK	1	25.863	29.037	31.607
	2	10.801	12.481	15.516
	3	681.519	691.755	707.056
DEPTH	1	25.863	29.037	31.607
	2	40.880	41.518	42.936
	3	723.740	733.273	748.306


NWRZ3
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
52.7
OHM-M
49.0 M
343.
OHM-M
349. M
4.66
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 2.34
CALIBRATION: 1
OFFSET: 151 M
RAMP: 155.0

NWRZ3

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		339.9	1115.0		
52.69	49.0	290.8	954.2	0.9	0.9
343.21	348.7	-57.8	-189.8	1.0	1.9
4.66					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	2.28E+02	2.26E+02	0.754	
2	1.10E-04	1.98E+02	1.99E+02	-0.576	
3	1.40E-04	1.78E+02	1.79E+02	-0.814	
4	1.77E-04	1.66E+02	1.67E+02	-0.806	
5	2.20E-04	1.61E+02	1.62E+02	-0.567	
6	2.80E-04	1.61E+02	1.60E+02	0.524	
7	3.55E-04	1.65E+02	1.64E+02	0.560	
8	4.43E-04	1.74E+02	1.72E+02	1.220	
9	5.64E-04	1.85E+02	1.84E+02	0.431	
10	7.13E-04	2.00E+02	1.99E+02	0.519	
11	8.81E-04	2.09E+02	2.11E+02	-0.980	
12	1.10E-03	2.16E+02	2.16E+02	-0.028	
13	1.40E-03	1.96E+02	2.05E+02	-4.676	
14	1.41E-03	2.13E+02	2.05E+02	4.216	
15	1.77E-03	1.80E+02	1.81E+02	-0.966	
16	2.20E-03	1.56E+02	1.54E+02	0.981	
17	2.80E-03	1.27E+02	1.25E+02	1.408	
18	3.55E-03	1.01E+02	1.01E+02	0.004	
19	4.43E-03	8.26E+01	8.25E+01	0.073	
20	5.64E-03	6.69E+01	6.66E+01	0.361	
21	7.13E-03	5.44E+01	5.45E+01	-0.131	
22	8.81E-03	4.49E+01	4.58E+01	-1.915	
23	1.10E-02	3.89E+01	3.85E+01	0.874	

R: 151. X: 0. Y: 151. DL: 302. REQ: 168. CF: 1.0000
CLHZ ARRAY, 23 DATA POINTS, RAMP: 155.0 MICROSEC, DATA: NWRZ3
1808 WR 300WZ OPR XTL L 5 8 -100=302*302
Ch.21 = 0.155 Ch.22 = 0.89 Ch.23 = 14.5 Ch.24 =
RMS LOG ERROR: 1.00E-02, ANTILOG YIELDS 2.3362 %
LATE TIME PARAMETERS

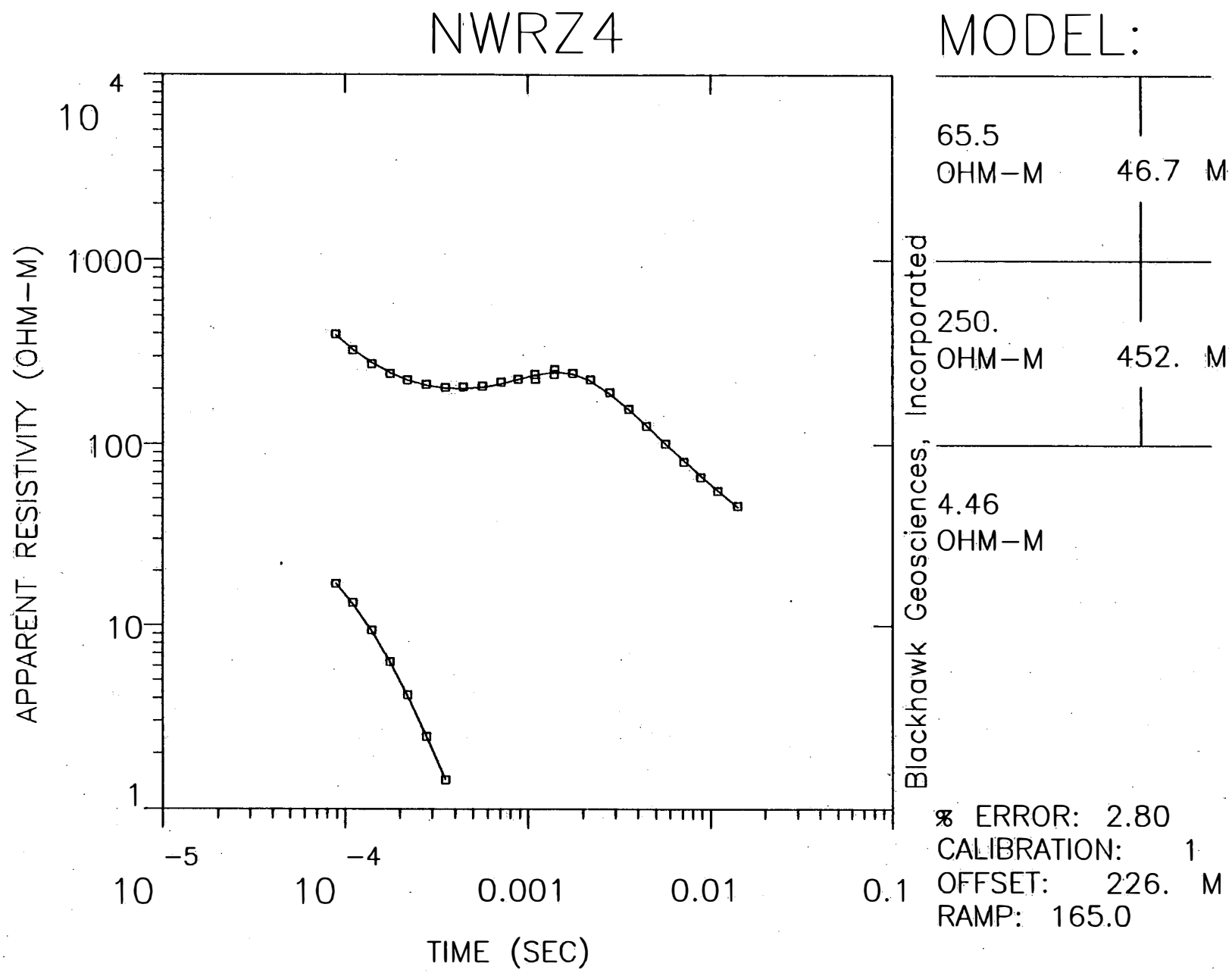
* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.99				
P 2	-0.02	0.94			
P 3	0.00	-0.01	1.00		
T 1	-0.02	-0.05	0.00	0.95	
T 2	0.00	0.01	0.00	0.01	1.00
	P 1	P 2	P 3	T 1	T 2

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	51.112	52.691	55.099
	2	315.767	343.207	383.544
	3	4.397	4.658	4.946
THICK	1	45.892	49.025	54.018
	2	343.071	348.667	352.531
DEPTH	1	45.892	49.025	54.018
	2	396.982	397.693	398.525



MODEL:

65.5 OHM-M — 46.7 M

250. OHM-M — 452. M

4.46 OHM-M

Blackhawk Geosciences, Incorporated

% ERROR: 2.80
CALIBRATION: 1
OFFSET: 226. M
RAMP: 165.0

NWRZ4

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		410.0	1345.0		
65.51	46.7	363.3	1191.9	0.7	0.7
249.61	452.5	-89.2	-292.6	1.8	2.5
4.46					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	3.95E+02	3.94E+02	0.380	
2	1.10E-04	3.25E+02	3.28E+02	-1.131	
3	1.40E-04	2.74E+02	2.78E+02	-1.215	
4	1.77E-04	2.42E+02	2.45E+02	-1.133	
5	2.20E-04	2.23E+02	2.25E+02	-0.619	
6	2.80E-04	2.11E+02	2.10E+02	0.618	
7	3.55E-04	2.04E+02	2.03E+02	0.884	
8	4.43E-04	2.05E+02	2.01E+02	1.902	
9	5.64E-04	2.08E+02	2.05E+02	1.732	
10	7.13E-04	2.18E+02	2.14E+02	1.970	
11	8.81E-04	2.27E+02	2.26E+02	0.521	
12	1.10E-03	2.41E+02	2.39E+02	0.731	
13	1.10E-03	2.26E+02	2.39E+02	-5.310	
14	1.40E-03	2.41E+02	2.48E+02	-2.822	
15	1.41E-03	2.57E+02	2.48E+02	3.611	
16	1.77E-03	2.43E+02	2.42E+02	0.458	
17	2.20E-03	2.25E+02	2.22E+02	1.549	
18	2.80E-03	1.92E+02	1.89E+02	1.739	
19	3.55E-03	1.56E+02	1.55E+02	0.596	
20	4.43E-03	1.26E+02	1.27E+02	-0.653	
21	5.64E-03	1.01E+02	1.01E+02	-0.313	
22	7.13E-03	8.03E+01	8.15E+01	-1.472	
23	8.81E-03	6.58E+01	6.74E+01	-2.271	
24	1.10E-02	5.55E+01	5.57E+01	-0.260	
25	1.41E-02	4.58E+01	4.50E+01	1.768	

R: 226. X: 0. Y: 227. DL: 453. REQ: 252. CF: 1.0000
CLHZ ARRAY, 25 DATA POINTS, RAMP: 165.0 MICROSEC, DATA: NWRZ4
1808 WR 400WZ OPR XTL L 6 8 -100
Ch.21 = 0.165 Ch.22 = 0.89 Ch.23 = 11 Ch.24 = 2
RMS LOG ERROR: 1.20E-02, ANTILOG YIELDS 2.7956 %
LATE TIME PARAMETERS

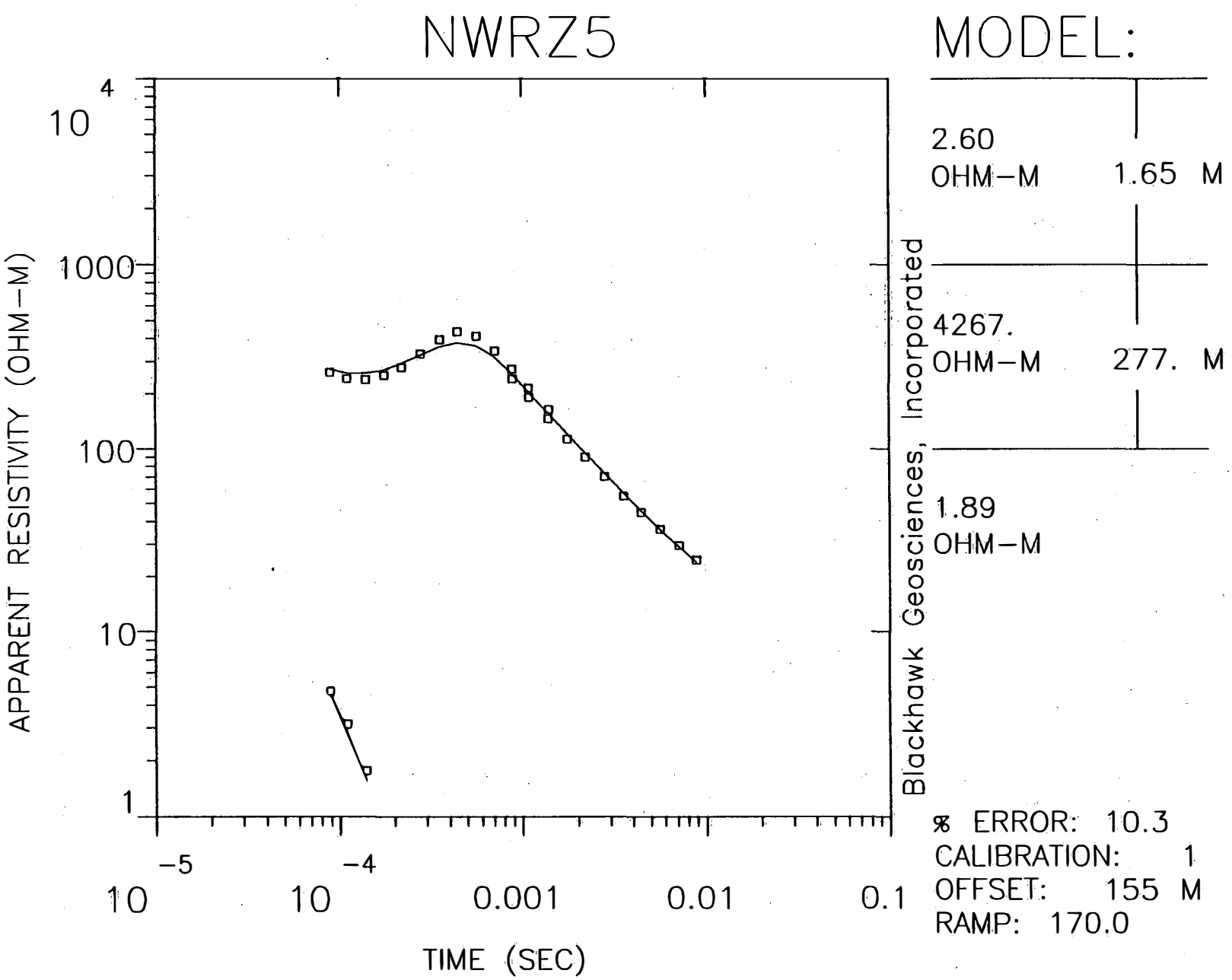
* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.87				
P 2	-0.07	0.92			
P 3	-0.01	-0.06	0.82		
T 1	-0.24	-0.17	-0.05	0.50	
T 2	0.03	0.02	0.01	0.06	0.99
	P 1	P 2	P 3	T 1	T 2

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	56.393	65.509	80.999
	2	229.555	249.607	292.663
	3	3.622	4.460	5.501
THICK	1	35.057	46.666	72.656
	2	426.011	452.461	468.302
DEPTH	1	35.057	46.666	72.656
	2	498.668	499.127	503.419


NWRZ5
MODEL:
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
2.60
OHM-M
1.65 M
4267.
OHM-M
277. M
1.89
OHM-M
Blackhawk Geosciences, Incorporated
% ERROR: 10.3
CALIBRATION: 1
OFFSET: 155 M
RAMP: 170.0

NWRZ5

MODEL: 3 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		246.0	807.0		
2.60	1.7	244.3	801.6	0.6	0.6
4267.23	277.2	-32.9	-107.8	0.1	0.7
1.89					

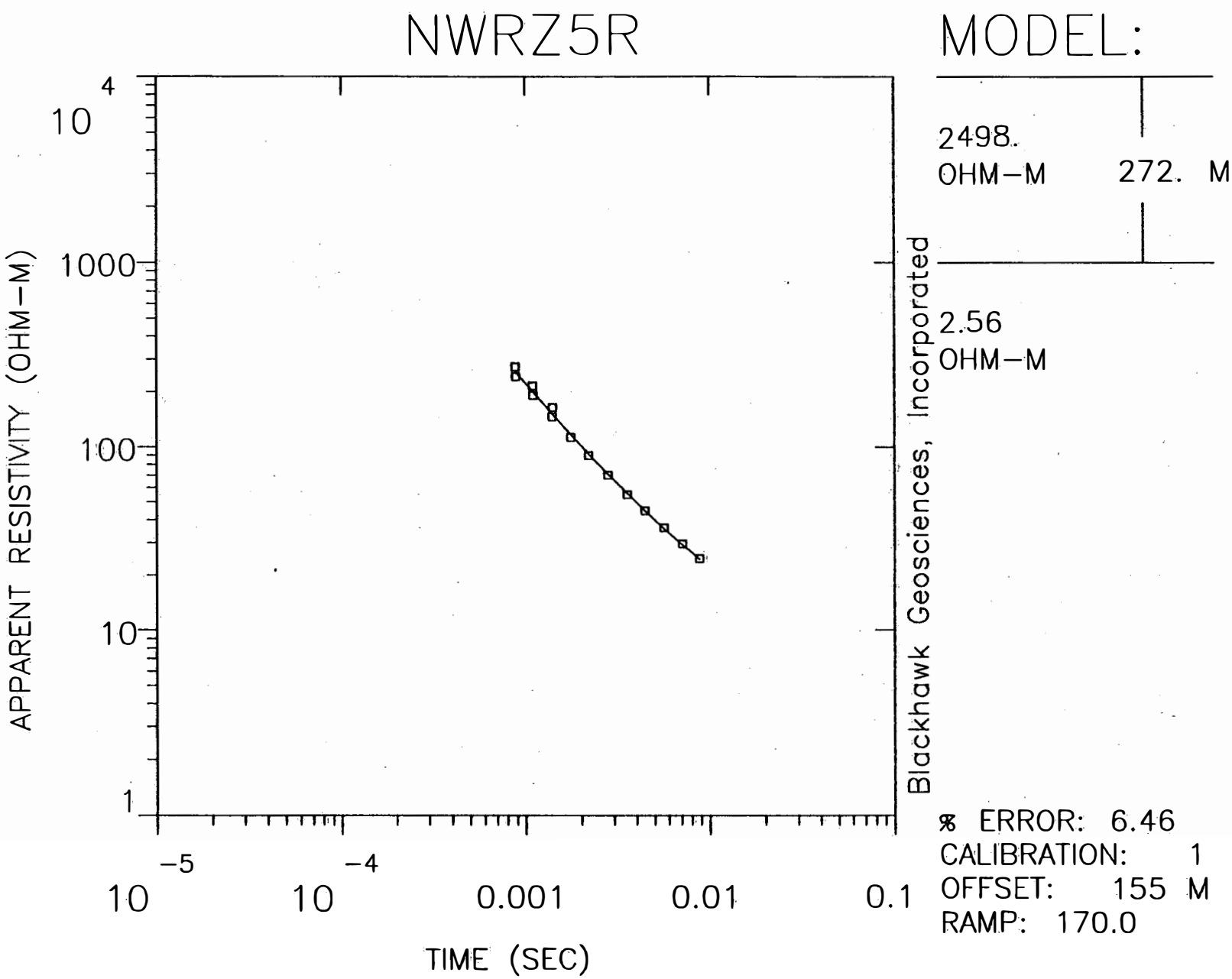
	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.90E-05	2.61E+02	2.72E+02	-3.958	
2	1.10E-04	2.41E+02	2.59E+02	-6.791	
3	1.40E-04	2.37E+02	2.58E+02	-8.065	
4	1.77E-04	2.51E+02	2.70E+02	-7.148	
5	2.20E-04	2.78E+02	2.91E+02	-4.579	
6	2.80E-04	3.30E+02	3.24E+02	1.651	
7	3.55E-04	3.93E+02	3.60E+02	9.193	
8	4.43E-04	4.35E+02	3.79E+02	14.704	
9	5.64E-04	4.11E+02	3.65E+02	12.712	
10	7.13E-04	3.41E+02	3.14E+02	8.744	
11	8.81E-04	2.72E+02	2.57E+02	6.094	
12	8.90E-04	2.41E+02	2.54E+02	-4.967	
13	1.10E-03	2.14E+02	2.03E+02	5.507	
14	1.10E-03	1.91E+02	2.02E+02	-5.830	
15	1.40E-03	1.46E+02	1.55E+02	-6.187	
16	1.41E-03	1.64E+02	1.54E+02	6.242	
17	1.77E-03	1.13E+02	1.20E+02	-6.121	
18	2.20E-03	8.94E+01	9.47E+01	-5.574	
19	2.80E-03	7.01E+01	7.31E+01	-4.175	
20	3.55E-03	5.48E+01	5.71E+01	-3.934	
21	4.43E-03	4.47E+01	4.56E+01	-1.982	
22	5.64E-03	3.60E+01	3.60E+01	0.030	
23	7.13E-03	2.95E+01	2.88E+01	2.370	
24	8.81E-03	2.45E+01	2.38E+01	2.997	

R: 155. X: 0. Y: 155. DL: 310. REQ: 172. CF: 1.0000
CLHZ ARRAY, 24 DATA POINTS, RAMP: 170.0 MICROSEC, DATA: NWRZ5
1908 WR 500NZ OPR XTL L 6 8 -100=310*310
Ch.21 = 0.17 Ch.22 = 0.89 Ch.23 = 14.25 Ch.24 =
RMS LOG ERROR: 4.25E-02, ANTILOG YIELDS 10.2924 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

P 1	0.49				
P 2	0.01	0.00			
P 3	0.00	0.00	0.07		
T 1	-0.46	-0.01	0.03	0.49	
T 2	0.00	0.00	-0.04	-0.01	0.96
	P 1	P 2	P 3	T 1	T 2


NWRZ5R
MODEL:
2498.
OHM-M
272. M
2.56
OHM-M
APPARENT RESISTIVITY (OHM-M)
10^4
1000
100
10
1
10^-5
10^-4
0.001
0.01
0.1
TIME (SEC)
Blackhawk Geosciences, Incorporated
% ERROR: 6.46
CALIBRATION: 1
OFFSET: 155 M
RAMP: 170.0

NWRZ5R

MODEL: 2 LAYERS

RESISTIVITY (OHM-M)	THICKNESS (M)	ELEVATION (M)	ELEVATION (FEET)	CONDUCTANCE (S) LAYER	CONDUCTANCE (S) TOTAL
		246.0	807.0		
2497.70	272.4	-26.4	-86.6	0.1	0.1
2.56					

	TIMES	DATA	CALC	% ERROR	STD ERR
1	8.81E-04	2.72E+02	2.59E+02	5.226	
2	8.90E-04	2.41E+02	2.56E+02	-5.597	
3	1.10E-03	2.14E+02	2.00E+02	7.137	
4	1.10E-03	1.91E+02	1.99E+02	-4.350	
5	1.40E-03	1.46E+02	1.51E+02	-3.559	
6	1.41E-03	1.64E+02	1.50E+02	9.245	
7	1.77E-03	1.13E+02	1.16E+02	-3.073	
8	2.20E-03	8.94E+01	9.17E+01	-2.543	
9	2.80E-03	7.01E+01	7.11E+01	-1.470	
10	3.55E-03	5.48E+01	5.59E+01	-1.837	
11	4.43E-03	4.47E+01	4.50E+01	-0.625	
12	5.64E-03	3.60E+01	3.58E+01	0.355	
13	7.13E-03	2.95E+01	2.91E+01	1.546	
14	8.81E-03	2.45E+01	2.43E+01	0.996	

R: 155. X: 0. Y: 155. DL: 310. REQ: 172. CF: 1.0000
CLHZ ARRAY, 14 DATA POINTS, RAMP: 170.0 MICROSEC, DATA: NWRZ5R
1908 WR 500NZ OPR XTL L 6 8 -100=310*310
Ch.21 = 0.17 Ch.22 = 0.89 Ch.23 = 14.25 Ch.24 =
RMS LOG ERROR: 2.72E-02, ANTILOG YIELDS 6.4572 %
LATE TIME PARAMETERS

* Blackhawk Geosciences, Incorporated *

PARAMETER RESOLUTION MATRIX:
"F" MEANS FIXED PARAMETER

	P 1	P 2	T 1
P 1	0.03		
P 2	-0.02	1.00	
T 1	0.00	0.00	1.00

PARAMETER BOUNDS FROM EQUIVALENCE ANALYSIS

	LAYER	MINIMUM	BEST	MAXIMUM
RHO	1	321.113	2497.699	8814.285
	2	1.775	2.555	3.066
THICK	1	270.010	272.378	276.276
DEPTH	1	270.010	272.378	276.276